AMERICAN SOCIETY
FOR
TESTING MATERIALS

PROCEEDINGS
OF THE
THIRTY-SEVENTH ANNUAL MEETING

Held at Atlantic City, N. J.
June 25-29, 1934

VOLUME 34
COMMITTEE REPORTS
PART I. NEW AND REVISED TENTATIVE STANDARDS
TENTATIVE REVISIONS OF STANDARDS

Published by
AMERICAN SOCIETY FOR TESTING MATERIALS
260 S. Broad Street, Philadelphia, Pa

TA401
.A5

Copyright, 1934
by the
AMERICAN SOCIETY FOR TESTING MATERIALS

Printed in Philadelphia, U. S. A.
December, 1934

CclA 80214

JAN 25 1935

CONTENTS

PROCEEDINGS, PART I

PAGE

Summary of the Proceedings of the Thirty-seventh Annual Meeting.......... 1
Annual Address by the President—Thomas R. Lawson.......... 27
Annual Report of the Executive Committee.......... 35

COMMITTEE REPORTS

FERROUS METALS

Report of Committee A-1 on Steel.......... 60
  Appendix. Proposed Revisions in Standards and Tentative Standards for Steel.......... 75
  Discussion.......... 84
Report of Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel:
  Effect of Sulfur on Forging Steel.......... 87
  Effect of Added Phosphorus on Low-Carbon Steel.......... 113
    Discussion.......... 122
Report of Sectional Committee on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing.......... 124
Report of Committee A-2 on Wrought Iron.......... 126
  Quality Standards for Wrought Iron—Report of Special Subcommittee of Subcommittee X on Research.......... 129
Report of Committee A-3 on Cast Iron.......... 145
  Report of Special Subcommittee on Test Bars.......... 148
Report of Committee A-5 on Corrosion of Iron and Steel.......... 154
  Report of Subcommittee V on Total Immersion Tests.......... 157
  Report of Subcommittee VI on Specifications for Metallic-Coated Products. 158
  Report of Subcommittee VIII on Field Tests of Metallic Coatings.......... 159
    Appendix. Wire Test Program.......... 172
  Report of Subcommittee X on Embrittlement Investigation.......... 184
Report of Committee A-6 on Magnetic Properties.......... 186
Report of Committee A-9 on Ferro-Alloys.......... 188
Report of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys.......... 190
  Appendix. The Polishing and Etching of Iron-Chromium and Iron-Chromium-Nickel Alloys—J. R. Vilella.......... 193
Report of Research Committee on Fatigue of Metals.......... 205
Report of Joint Research Committee on Effect of Temperature on the Properties of Metals.......... 207
  Appendix. Proposed Revisions in Tentative Methods for High-Temperature Tension Tests of Metallic Materials.......... 213

PAGE

NON-FERROUS METALS

Report of Committee B-2 on Non-Ferrous Metals and Alloys................ 217
Report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys..... 221
Report of Subcommittee VII on Corrosion in Liquids................... 222
Report of Subcommittee VIII on Galvanic and Electrolytic Corrosion..... 236
Report of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys.. 244
Report of Committee B-5 on Copper and Copper Alloys, Cast and Wrought... 249
Report of Committee B-6 on Die-Cast Metals and Alloys................... 251
Report of Subcommittee V on Exposure and Corrosion Tests............. 255
Appendix. The Effect of Variations in Aluminum Content on the Strength and Permanence of the A.S.T.M. No. XXIII Zinc Die-Casting Alloy—E. A. Anderson and G. L. Werley.................................. 261
Discussion.. 270
Report of Committee B-7 on Light Metals and Alloys, Cast and Wrought..... 272
Appendix. Service Characteristics of the Light Metals and Their Alloys.. 277

CEMENTITIOUS, CERAMIC, CONCRETE AND MASONRY MATERIALS

Report of Committee C-1 on Cement.. 307
Report on Cooperative Sub-Sieve Fineness Tests by the Working Committee on Fineness.. 315
Report of Working Committee on Plastic Mortar Tests for Portland Cement 322
Report of Working Committee on Volume Change and Soundness of Portland Cement.. 356
Report of Subcommittee on Cement Reference Laboratory.............. 361
Report of Committee C-3 on Brick.. 364
Report of Committee C-7 on Lime.. 366
Report of Committee C-8 on Refractories.................................... 369
Appendix. Pyrometric Cone Equivalent *versus* Fusion Point—A Question of Nomenclature—F. A. Harvey.................................. 376
Report of Committee C-9 on Concrete and Concrete Aggregates.............. 378
Appendix I. Comparison of Standards for Colorimetric Test for Sand—Abstract of Unpublished Paper by C. L. Ford.......................... 381
Appendix II. A Study of the Permeability of a Few Integrally Waterproofed Concretes—W. M. Dunagan and G. C. Ernst................. 383
Report of Committee C-10 on Hollow Masonry Building Units.............. 393
Report of Committee C-11 on Gypsum....................................... 395
Report of Committee C-13 on Concrete Pipe................................ 397

MISCELLANEOUS MATERIALS: PRESERVATIVE COATINGS, ETC.

Report of Committee D-1 on Preservative Coatings for Structural Materials.. 400
Report of Subcommittee VIII on Methods of Analysis of Paint Materials.. 407
Report of Subcommittee XIII on Shellac.................................. 412
Report of Subcommittee XV on Specifications for Pigments Dry and in Oil when Marketed in That Form....................................... 414
Report of Subcommittee XXV on Cellulose Ester Coatings............... 416
Report of Committee D-2 on Petroleum Products and Lubricants............ 418
Report of Technical Committee A on Gasoline.......................... 435
Appendix. Diesel-Fuel-Oil Classification............................... 440
Report of Committee D-4 on Road and Paving Materials.................... 444
Report of Subcommittee B-3 on Distillation.............................. 448

PAGE

Report of Committee D-5 on Coal and Coke 451
  Appendix. Proposed Method of Test for Agglutinating Value of Coal.... 457
Report of Sectional Committee on Classification of Coals 463
  Report of the Technical Committee on Scientific Classification 469
  Report of the Technical Committee on Nomenclature 475
  Report of the Technical Committee on Coal Classification 478
Report of Committee D-7 on Timber 481
Report of Committee D-8 on Bituminous Waterproofing and Roofing Materials 483
  Report of Subcommittee X on Standard Coefficient of Expansion for Bituminous Products 486
Report of Committee D-9 on Electrical Insulating Materials 488
  Appendix. Modified Baader Saponification Test for Electrical Insulating Oils 511
Report of Committee D-11 on Rubber Products 513
  Appendix I. Proposed Specifications for Rubber Insulating Blankets for Use Around Electrical Apparatus or Circuits not Exceeding 3000 Volts to Ground 522
  Appendix II. Proposed Method for Testing the Adhesion of Rubber to Metal—A. H. Flower and H. E. Wening 525
Report of Committee D-13 on Textile Materials 532
Report of Committee D-15 on Thermometers and Laboratory Glassware...... 543
Report of Committee D-17 on Naval Stores 545
  Report of Subcommittee II on Crystallization 546
Report of Committee D-19 on Water for Industrial Uses 551

MISCELLANEOUS SUBJECTS

Report of Committee E-1 on Methods of Testing 553
  Appendix. Discussion on Use of the Tension Test for Judging the Suitability of Sheet Metals for Various Purposes 563
Report of Committee E-4 on Metallography 571
Report of Committee E-6 on Papers and Publications 573
Report of Committee E-8 on Nomenclature and Definitions 576
Report of Committee E-9 on Research 579
Report of Committee E-10 on Standards 582

A.S.T.M. TENTATIVE STANDARDS

ISSUED OR REVISED, 1934

A. FERROUS METALS

STEEL

Strip Steel

Tentative Specifications for:

A 109 – 34 T. Cold-Rolled Strip Steel 591

Steel Pipe

Tentative Specifications for:

A 139 – 34 T. Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) 598
A 155 – 34 T. Electric-Fusion-Welded Steel Pipe for High-Temperature and High-Pressure Service *628*

Tentative Specifications for: PAGE

A 106 – 34 T. Lap-Welded and Seamless Steel Pipe for High-Temperature Service 637

A 158 – 34 T. Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F 617

A 120 – 34 T. Welded and Seamless Steel Pipe for Ordinary Uses, Black and Hot-Dipped Zinc-Coated (Galvanized) 604

Steel for High-Temperature Service

Tentative Specifications for:

A 157 – 34 T. Castings, Alloy-Steel, for Valves, Flanges and Fittings for Service at Temperatures from 750 to 1100 F 609

A 158 – 34 T. Pipe, Seamless Alloy-Steel, for Service at Temperatures from 750 to 1100 F 617

A 155 – 34 T. Pipe, Electric-Fusion-Welded Steel, for High-Temperature and High-Pressure Service 628

A 106 – 34 T. Pipe, Lap-Welded and Seamless Steel, for High-Temperature Service 637

Tentative Methods of:

E 21 – 34 T. Tension Tests, Short-Time High-Temperature, of Metallic Materials, Test for 1214

E 22 – 34 T. Tension Tests, Long-Time (Creep) High-Temperature, of Metallic Materials, Test for 1223

WROUGHT IRON

Tentative Specifications for:

A 42 – 34 T. Wrought-Iron Plates 648

CAST IRON

Tentative Specifications for:

A 142 – 34 T. Cast-Iron Culvert Pipe 654

FERRO-ALLOYS

Tentative Method of:

A 156 – 34 T. Sampling Molybdenum Salts and Compounds for Metallurgical Use 660

FERROUS METALS, GENERAL

Tentative Methods of:

E 23 – 34 T. Impact Testing of Metallic Materials 1201

E 21 – 34 T. Tension Tests, Short-Time High-Temperature, of Metallic Materials, Test for 1214

E 22 – 34 T. Tension Tests, Long-Time (Creep) High-Temperature, of Metallic Materials, Test for 1223

E 4 – 34 T. Verification of Testing Machines 1233

B. NON-FERROUS METALS

LEAD

Tentative Specifications for:

B 29 – 34 T. Pig Lead 662

ALUMINUM AND ALUMINUM ALLOYS

Tentative Specifications for: PAGE

B 25 – 34 T. Sheet and Plate, Aluminum.......................... 668
B 79 – 34 T. Sheet and Plate, Aluminum-Manganese Alloy............ 673

MAGNESIUM AND MAGNESIUM ALLOYS

Tentative Specifications for:

B 94 – 34 T. Die Castings, Magnesium-Base Alloy.................... 703
B 91 – 34 T. Forgings, Magnesium-Base Alloy....................... 678
B 93 – 34 T. Ingot for Remelting, Magnesium-Base Alloy............ 682
B 80 – 34 T. Sand Castings, Magnesium-Base Alloy.................. 684
B 90 – 34 T. Sheet, Magnesium-Base Alloy.......................... 688

COPPER AND COPPER ALLOYS

Copper Wire and Cable

Tentative Specifications for:

D 27 – 34 T. Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound..................................1101
D 393 – 34 T. Insulated Wire and Cable: Class A, 30 per cent Hevea Rubber Compound..................................1126
D 353 – 34 T. Insulated Wire and Cable: Performance Rubber Compound1128

Copper-Silicon Alloys

Tentative Specifications for:

B 96 – 34 T. Plates and Sheets, Copper-Silicon Alloy................ 692
B 98 – 34 T. Rods, Bars and Shapes, Copper-Silicon Alloy............ 695
B 97 – 34 T. Sheet Copper-Silicon Alloy............................. 699

DIE CASTINGS

Tentative Specifications for:

B 94 – 34 T. Magnesium-Base Alloy Die Castings.................... 703
B 86 – 34 T. Zinc-Base Alloy Die Castings......................... 706

ELECTRICAL-HEATING AND ELECTRICAL-RESISTANCE ALLOYS

Tentative Methods of:

B 71 – 34 T. Chemical Analysis of Metallic Materials for Electrical Heating... 710
B 95 – 34 T. Linear Expansion of Metals, Test for.................. 733
E 21 – 34 T. Tension Tests, Short-Time High-Temperature, of Metallic Materials, Test for..................................1214

NON-FERROUS METALS, GENERAL

Tentative Methods of:

E 23 – 34 T. Impact Testing of Metallic Materials....................1201
B 95 – 34 T. Linear Expansion of Metals, Test for.................... 733
E 4 – 34 T. Verification of Testing Machines 1233

C. CEMENTITIOUS, CERAMIC, CONCRETE AND MASONRY MATERIALS

CEMENT

Tentative Method of:

PAGE
C 109 – 34 T. Compressive Strength of Portland-Cement Mortars, Test for 743

LIME

Tentative Specifications for:

C 5 – 34 T. Quicklime for Structural Purposes 749
C 6 – 34 T. Hydrated Lime for Structural Purposes 752

Tentative Methods of:

C 110 – 34 T. Physical Test for Limestone, Quicklime and Hydrated Lime 754

MASONRY BUILDING UNITS

Building Tile

Tentative Specifications for:

C 57 – 34 T. Clay Floor Tile, Structural 761
C 56 – 34 T. Clay Non-Load-Bearing Tile, Structural 765
C 34 – 34 T. Clay Load-Bearing Wall Tile, Structural 768
C 90 – 34 T. Concrete Masonry Units, Load-Bearing 772

Tentative Methods of:

C 112 – 34 T. Sampling and Testing Structural Clay Tile 776

REFRACTORIES, FIRE BRICK

Tentative Specifications for:

C 105 – 34 T. Ground Fire Clay 780
C 106 – 34 T. Refractories for the Construction of Incinerators 782

Tentative Methods of:

C 18 – 34 T. Chemical Analysis of Magnesite Refractories 784
C 93 – 34 T. High-Temperature Heat Insulation (Compression, Flexure, Shrinkage), Testing of 791
C 38 – 34 T. Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling 796
C 107 – 34 T. Panel Test for Resistance to Thermal and Structural Spalling of Fire-Clay Brick for Stationary Boilers and Malleable Iron Furnace Bungs 804

Tentative Definitions of:

C 71 – 34 T. Refractories, Terms Relating to 806
C 108 – 34 T. Heat Transmission, Symbols for 807

CONCRETE PIPE

Tentative Specifications for:

C 14 – 34 T. Non-Reinforced Concrete Sewer Pipe 809
C 75 – 34 T. Reinforced-Concrete Sewer Pipe 822

CONCRETE AND CONCRETE AGGREGATES

Tentative Specifications for: PAGE

C 90 – 34 T. Masonry Units, Load-Bearing Concrete 772
C 14 – 34 T. Pipe, Sewer, Non-Reinforced Concrete 809
C 75 – 34 T. Pipe, Sewer, Reinforced-Concrete 822
C 111 – 34 T. Sodium Silicate for Curing Concrete 833

D. MISCELLANEOUS MATERIALS

COAL AND COKE

Tentative Specifications for:

D 388 – 34 T. Classification of Coals by Rank 834
D 389 – 34 T. Classification of Coals by Grade 841

TIMBER AND TIMBER PRESERVATIVES

Tentative Specifications for:

D 390 – 34 T. Creosote 843
D 391 – 34 T. Creosote Coal-Tar Solution 845
D 25 – 34 T. Timber Piles 847

PRESERVATIVE COATINGS: PIGMENTS, PAINTS, VARNISHES, LACQUERS AND PAINT MATERIALS

Pigments

Tentative Specifications for:

D 382 – 34 T. Titanium Barium Pigment 856
D 383 – 34 T. Titanium Calcium Pigment 858
D 384 – 34 T. Titanium Dioxide 860
D 385 – 34 T. High Zinc Sulfide Lithopone 862
D 386 – 34 T. Zinc Sulfide 864

Tentative Methods of:

D 332 – 34 T. Tinting Strength of White Pigments or White Pigment Pastes, Test for 866
D 387 – 34 T. Mass Color and Tinting Strength of Dry Color Pigments or Pastes, Test for 871

Paint Thinners

Tentative Specifications for:

D 235 – 34 T. Petroleum Spirits (Mineral Spirits) 876

Varnishes

Tentative Methods of:

D 115 – 34 T. Varnishes Used for Electrical Insulation, Testing of 1082

Lacquer and Lacquer Materials

Tentative Specifications for:

D 318 – 34 T. Amyl Acetate (From Fusel Oil) (85 to 88 per cent Grade) .. 878

Tentative Methods of: PAGE

D 333 – 34 T. Nitrocellulose Clear Lacquers and Lacquer Enamels, Testing of 879

PETROLEUM PRODUCTS AND LUBRICANTS

See also **Waterproofing and Roofing Materials**

Tentative Specifications for:

D 396 – 34 T. Fuel Oils 882
D 397 – 34 T. Emulsified Asphalt (For Coarse Aggregate Plant Mixes) *916*
D 398 – 34 T. Emulsified Asphalt (For Retread and Coarse Aggregate Mixes) *918*
D 399 – 34 T. Emulsified Asphalt (Heavy Premix—Summer Grade) *920*
D 400 – 34 T. Emulsified Asphalt (Heavy Premix—Winter Grade) *922*
D 401 – 34 T. Emulsified Asphalt ((Quick-Setting) for Penetration and Surface Treatment) *924*

Tentative Methods of:

D 155 – 34 T. Color of Lubricating Oils by Means of A.S.T.M. Union Colorimeter, Test for 885
D 218 – 34 T. Color of Petrolatum by Means of A.S.T.M. Union Colorimeter, Test for 890
D 156 – 34 T. Color of Refined Petroleum Oil by Means of Saybolt Chromometer, Test for 895
D 244 – 34 T. Emulsified Asphalts, Testing of *926*
D 381 – 34 T. Gum Content of Gasoline, Test for 899
D 357 – 34 T. Knock Characteristics of Motor Fuels, Test for 902
D 402 – 34 T. Liquid Asphaltic Products, Test for Separation of *938*
D 90 – 34 T. Sulfur in Petroleum Oils by Lamp Method, Test for 911

ROAD MATERIALS

Tentative Specifications for:

D 397 – 34 T. Emulsified Asphalt (For Coarse Aggregate Plant Mixes) .. 916
D 398 – 34 T. Emulsified Asphalt (For Retread and Coarse Aggregate Mixes) 918
D 399 – 34 T. Emulsified Asphalt (Heavy Premix—Summer Grade) 920
D 400 – 34 T. Emulsified Asphalt (Heavy Premix—Winter Grade) 922
D 401 – 34 T. Emulsified Asphalt ((Quick-Setting) for Penetration and Surface Treatment) 924
C 111 – 34 T. Sodium Silicate for Curing Concrete *833*

Tentative Methods of:

D 244 – 34 T. Emulsified Asphalts, Testing of 926
D 402 – 34 T. Separation of Liquid Asphaltic Products, Test for 938

WATERPROOFING AND ROOFING MATERIALS

Tentative Specifications for:

D 225 – 34 T. Asphalt Shingles, Surfaced with Coarse Mineral Granules **944**
D 224 – 34 T. Asphalt Roofing, Surfaced with Powdered Talc or Mica .. **947**

Tentative Specifications for: PAGE

D 248 – 34 T. Asphalt Roofing, Surfaced with Fine Mineral Granules... 951
D 249 – 34 T. Asphalt Roofing, Surfaced with Coarse Mineral Granules 955

Tentative Methods of:

D 244 – 34 T. Emulsified Asphalts, Testing of.......................... 926

ELECTRICAL INSULATING MATERIALS

Tentative Specifications for:

D 375 – 34 T. Asbestos Roving....................................1169
D 27 – 34 T. Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound..................................1101
D 393 – 34 T. Insulated Wire and Cable: Class A, 30 per cent Hevea Rubber Compound....................................1126
D 353 – 34 T. Insulated Wire and Cable: Performance Rubber Compound.1128
D 373 – 34 T. Tape, Black Bias-Cut Varnished Cloth, Used for Electrical Insulation.. 959
D 69 – 34 T. Tape, Friction, for General Use for Electrical Purposes.....1139
D 119 – 34 T. Tape, Rubber Insulating................................1145

Tentative Methods of:

D 176 – 34 T. Compounds, Solid Filling and Treating, Used for Electrical Insulation.. 965
D 149 – 34 T. Dielectric Strength, Testing Sheet, Tape, and Molded Insulating Materials for................................ 982
D 256 – 34 T. Impact of Electrical Insulating Materials, Tests for Resistance to.. 995
D 392 – 34 T. Molding Powders Used in Manufacturing Molded Electrical Insulators, Testing of..........................1001
D 202 – 34 T. Paper, Untreated, Used in Electrical Insulation, Testing of1007
D 150 – 34 T. Power Factor and Dielectric Constant of Electrical Insulating Materials, Test for..........................1029
D 349 – 34 T. Rods, Laminated Round, Used in Electrical Insulation, Testing of..1051
D 229 – 34 T. Sheet and Plate Materials Used in Electrical Insulation, Testing of..1055
D 348 – 34 T. Tubes, Laminated, Used in Electrical Insulation, Testing of1064
D 374 – 34 T. Thickness of Solid Electrical Insulation, Test for.........1069
D 295 – 34 T. Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation, Testing of......................1074
D 115 – 34 T. Varnishes Used for Electrical Insulation, Testing of......1082

RUBBER PRODUCTS

Tentative Specifications for:

D 27 – 34 T. Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound..................................1101
D 393 – 34 T. Insulated Wire and Cable: Class A, 30 per cent Hevea Rubber Compound..................................1126
D 353 – 34 T. Insulated Wire and Cable: Performance Rubber Compound..1128

Tentative Specifications for: PAGE

D 69 – 34 T. Tape, Friction, for General Use for Electrical Purposes...1139
D 119 – 34 T. Tape, Rubber Insulating....1145

Tentative Methods of:

D 394 – 34 T. Abrasion Resistance of Rubber Compounds, Test for....1150
D 395 – 34 T. Compression Set of Vulcanized Rubber, Test for....1164

TEXTILE MATERIALS

Tentative Specifications for:

D 375 – 34 T. Asbestos Roving....1169
D 299 – 34 T. Asbestos Yarns....1172
D 376 – 34 T. Holland Cloth....1175
D 403 – 34 T. Woolen Yarns, Tolerances and Test Methods for....1178
D 404 – 34 T. Worsted Yarns, Tolerances and Test Methods for....1181

Tentative Methods of:

D 232 – 34 T. Estimating Hard Scoured Wool in Wool in the Grease ...1184

Tentative Definitions of:

D 123 – 34 T. Textile Materials, Terms Relating to....1186

E. GENERAL TESTING METHODS

Tentative Method of:

E 23 – 34 T. Impact Testing of Metallic Materials....1201
E 21 – 34 T. Tension Tests, Short-Time High-Temperature, of Metallic Materials, Test for....1214
E 22 – 34 T. Tension Tests, Long-Time (Creep) High-Temperature, of Metallic Materials, Test for....1223
E 4 – 34 T. Verification of Testing Machines....1233

Tentative Definitions of:

E 24 – 34 T. Consistency and Plasticity, Terms....1245

TENTATIVE REVISIONS OF A.S.T.M. STANDARDS

A. FERROUS METALS

Revisions of Standard Specifications for:

A 1 – 30. Open-Hearth Carbon-Steel Rails....1249
A 21 – 27. Carbon-Steel Car and Tender Axles....1250
A 19 – 27. Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars....1251
A 63 – 27. Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars....1252
A 25 – 24. Wrought Solid Carbon-Steel Wheels for Electric Railway Service....1252
A 31 – 24. Boiler Rivet Steel and Rivets....1254
A 141 – 33. Structural Rivet Steel....1254
A 131 – 33. Structural Steel for Ships....1254

Revisions of Standard Specifications for: PAGE

A 15 – 33. Billet-Steel Concrete Reinforcement Bars.................. 1255

A 16 – 33. Rail-Steel Concrete Reinforcement Bars.................. 1255

A 53 – 33. Welded and Seamless Steel Pipe.................. 1255

A 27 – 24. Carbon-Steel Castings.................. 1255

A 87 – 27. Carbon-Steel Castings for Railroads.................. 1256

A 95 – 33. Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service.................. 1256

A 96 – 33. Alloy-Steel Bolting Material for High-Temperature Service.. 1257

A 105 – 33. Forged or Rolled Steel Pipe Flanges for High-Temperature Service.................. 1257

A 46 – 24. Chilled Cast-Iron Wheels.................. 1258

A 116 – 30. Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing.................. 1258

A 121 – 30. Zinc-Coated (Galvanized) Iron or Steel Barbed Wire 1258

A 42 – 30. Wrought-Iron Plates.................. 1258

A 86 – 30. Hollow-Rolled Staybolt Iron.................. 1258

B. NON-FERROUS METALS

Revisions of Standard Specifications for:

B 62 – 28. Composition Brass or Ounce Metal Sand Castings.................. 1259

B 61 – 28. Steam or Valve Bronze Sand Castings.................. 1259

B 60 – 28. Sand Castings of the Alloy: Copper 88 per cent; Tin 8 per cent; Zinc 4 per cent.................. 1260

Revisions of Standard Methods of:

B 27 – 19. Chemical Analysis of Manganese Bronze.................. 1261

B 45 – 27. Chemical Analysis of Brass Ingots and Sand Castings.................. 1261

C. CEMENTITIOUS, CERAMIC, CONCRETE AND MASONRY MATERIALS

Revisions of Standard Specifications for:

C 5 – 26. Quicklime for Structural Purposes.................. 1261

C 6 – 31. Hydrated Lime for Structural Purposes.................. 1261

C 14 – 24. Cement-Concrete Sewer Pipe.................. 1262

C 63 – 28. Clay Fire Brick for Malleable Furnaces with Removable Bungs and for Annealing Ovens.................. 1262

C 64 – 28. Clay Fire Brick for Stationary Boiler Service.................. 1262

C 65 – 28. Clay Fire Brick for Marine Boiler Service.................. 1262

Revisions of Standard Methods of:

C 18 – 21. Ultimate Chemical Analysis of Refractory Materials, Including Chrome Ores and Chrome Brick.................. 1262

C 16 – 20. Test for Refractory Materials Under Load at High Temperatures.................. 1263

C 24 – 33. Test for Softening Point of Fire-Clay Brick.................. 1263

Revisions of Standard Definitions of:

C 27 – 28. Clay Refractories.................. 1264

C 71 – 31. Terms Relating to Refractories.................. 1265

C 11 – 28. Terms Relating to the Gypsum Industry.................. 1265

C 58 – 28. The Term Sand.................. 1265

D. MISCELLANEOUS MATERIALS

Revisions of Standard Specifications for: PAGE

D 318 – 33. Amyl Acetate (Synthetic)....1265

Revisions of Standard Methods of:

D 49 – 33. Routine Analysis of Dry Red Lead....1265
D 215 – 29. Routine Analysis of White Linseed Oil Paints....1266
D 126 – 27. Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green....1269

Revisions of Standard Definitions of:

D 16 – 24. Terms Relating to Paint Specifications....1271

Revisions of Standard Methods of:

D 322 – 33. Test for Dilution of Crankcase Oils....1272
D 86 – 30. Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products....1273
D 91 – 33. Test for Precipitation Number of Lubricating Oils....1273
D 96 – 30. Test for Water and Sediment in Petroleum Products by Means of Centrifuge....1273

Revisions of Standard Specifications for:

D 65 – 23. Broken Slag for Waterbound Base and Wearing Course....1273
D 66 – 23. Shovel-Run or Crusher-Run Broken Slag for Waterbound Base....1274
D 59 – 26. Block for Granite Block Pavements....1274
D 131 – 23. Block for Recut Granite Block Pavements....1274
D 132 – 23. Block for Durax Granite Pavements....1274
D 299 – 33. Asbestos Yarns....1274
D 316 – 34. Chafer Tire Fabrics....1275
D 274 – 34. Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics....1275

Revisions of Standard Methods of:

D 39 – 34. Testing Woven Textile Fabrics....1276
D 48 – 33. Testing Molded Materials Used for Electrical Insulation..1277

Revisions of Standard Definitions of:

D 121 – 30. Terms Relating to Coal and Coke....1278
D 324 – 33. Terms Relating to Timber Preservatives....1278

E. MISCELLANEOUS SUBJECTS

Revisions of Standard Definitions of:

E 6 – 30. Terms Relating to Methods of Testing....1279

Officers and Members of Executive Committee....1280
Subject Index....1281
Author Index....1319

INSERT PLATES

Plate I. Atmospheric Tests.... 156
Plate II. Total Immersion Tests.... 156
Plate III. Total Immersion Tests.... 156

American Society for Testing Materials

ORGANIZED IN 1898
INCORPORATED IN 1902

PROCEEDINGS, PART I

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

SUMMARY OF THE PROCEEDINGS OF THE THIRTY-SEVENTH ANNUAL MEETING

ATLANTIC CITY, N. J., JUNE 25–29, 1934

THE THIRTY-SEVENTH ANNUAL MEETING OF THE AMERICAN SOCIETY FOR TESTING MATERIALS was held at Chalfonte-Haddon Hall, Atlantic City, N. J., June 25–29, 1934. The following is an analysis of the registered attendance at the meeting: Members in attendance or represented, 721; guests, 102; total, 823; ladies, 132. The corresponding statistics for the Thirty-sixth Annual Meeting are: Members in attendance or represented, 614; guests, 89; total, 703; ladies, 70.

FIRST SESSION—TUESDAY, JUNE 26, 2 P. M.

Reports of Administrative Committees; Nomenclature and Testing

President T. R. Lawson in the chair.

President Lawson in opening the Thirty-seventh Annual Meeting called attention to the many contributions in materials standardization and in the furthering of knowledge concerning the materials of engineering as recorded in the annual reports of the committees and by the large number of technical papers on the program. It was pointed out that these accomplishments made during a period of unsettled industrial conditions were particularly commendable and were made possible only through the constant cooperation of the members of the standing committees. The large number of meetings being held by the committees and the active interest shown at these meetings gave promise of further valuable contributions to the Society in the future. President Lawson stressed the importance of the service which the Society is rendering to industry and the significance attached to its work in the field of engineering materials in advancing scientific progress.

In memory of three past presidents of the Society, A. A. Stevenson, J. H. Gibboney and T. D. Lynch, who passed away during the year, President Lawson spoke briefly of their sincere interest in the work of the Society and of their intimate association with its progress until the time of their passing.

The President appointed a Committee of Tellers, consisting of H. F. Moore, chairman, and J. B. Young, to canvass the vote on the election of officers, the report of the tellers to be received at the seventh session on Wednesday evening.

The minutes of the Thirty-sixth Annual Meeting were approved as printed in the 1933 *Proceedings*.[1]

The report of Committee E-6 on Papers and Publications was presented from manuscript by the chairman, C. L. Warwick.

The report of Committee E-9 on Research was presented from manuscript by the chairman, H. F. Moore.

The report of Committee E-10 on Standards was presented from manuscript by the chairman, Cloyd M. Chapman.

The report of the Executive Committee was presented by the Secretary-Treasurer, C. L. Warwick. The report discussed membership, committee activities, meetings of the Society, publications, finances, establishment of new Society headquarters, contacts with National Recovery Administration activities, and cooperative relations with other societies and the American Standards Association and participation of the Society in various cooperative international standardization activities.

The report of Committee E-8 on Nomenclature and Definitions was presented from manuscript by the secretary, R. E. Hess.

The report of Committee E-1 on Methods of Testing was presented from manuscript by the chairman, W. H. Fulweiler. In presenting the report Mr. Fulweiler called on H. F. Moore to describe the activities of the Technical Committee on Mechanical Testing, on E. C. Bingham to discuss the work of the Technical Committee on Consistency, Plasticity, etc., and on Anson Hayes to describe the work of the Technical Committee on Interpretation and Presentation of Data.

Past-President H. F. Moore then assumed the chair.

A paper entitled "Effect of Thickness on the Accuracy of Rockwell Hardness Tests on Thin Sheets," by R. L. Kenyon, was presented by the author and discussed.

A paper entitled "Characteristics of the Huggenberger Tensometer," by R. W. Vose, was presented by the author and discussed.

A paper entitled "The String Method of Measuring Deformations," by N. Davidenkoff, was presented from manuscript by Jesse Ormondroyd and discussed.

A paper entitled "Concerning the Effect of Notches and Laws of Similitude in Material Testing," by A. Nadai and C. W. MacGregor, was presented by Mr. Nadai and discussed.

A paper entitled "The Importance and the Determination of Particle Sizes of Hydraulic-Fill Dam Materials," by H. H. Hatch, was presented by L. T. Work and discussed.

The meeting then adjourned till 8 p. m.

---

[1] *Proceedings*, Am. Soc. Testing Mats,. Vol. 33, Part I, p. 1 (1933).

SECOND SESSION—TUESDAY, JUNE 26, 8 P. M.

Thermometers, Naval Stores, Paints

Vice-President Hermann von Schrenk in the chair.

The report of Committee D-15 on Thermometers and Laboratory Glassware was presented by the secretary, C. S. Reeve. The Tentative Specifications for Thermometers for Engler Viscosimeters (D 300 - 30 T) were approved for reference to letter ballot of the Society for adoption as standard. It was announced that an editorial revision in certain of the thermometer specifications was proposed to clarify the intent of the section on test for permanency of range and that the proposed modification was acceptable to the standing committees responsible for the specifications concerned.

The report of Committee D-17 on Naval Stores was presented by the chairman, F. P. Veitch.

The report of Committee D-1 on Preservative Coatings for Structural Materials was presented by the secretary, M. Rea Paul. The proposed Tentative Specifications for Titanium Barium Pigment, for Titanium Calcium Pigment, for Titanium Dioxide, for High Zinc Sulfide Lithopone, for Zinc Sulfide, for Amyl Acetate (from Fusel Oil) and Methods of Test for Mass Color and Tinting Strength of Dry Color Pigments or Pastes were accepted for publication as tentative.

The proposed revisions of the Standard Methods of Routine Analysis of Dry Red Lead (D 49 - 33), of White Linseed Oil Paints (D 215 - 29), of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 - 27) were accepted for publication as tentative. The proposed editorial revision of the Standard Methods of Sampling and Testing Shellac (D 29 - 33) was accepted. The proposed revisions of the Tentative Specifications for Petroleum Spirits (Mineral Spirits) (D 235 - 26 T), and the Methods of Test for Tinting Strength of White Pigments (D 332 - 31 T) and Tests for Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 - 33 T) were accepted, the specifications and methods as revised being continued as tentative.

The tentative revision of the Standard Specifications for Basic Carbonate White Lead (D 81 - 31) was approved for reference to letter ballot of the Society for adoption as standard. The Tentative Specifications for Shellac Varnish (D 359 - 33 T) and for Centrifuged Shellac Varnish (D 360 - 33 T), as revised, were approved for reference to letter ballot of the Society for adoption as standard. The Tentative Specifications for Spirits of Turpentine (D 13 - 33 T) were recommended on the floor of the annual meeting for adoption as standard and unanimously approved for reference to letter ballot of the Society, subject to favorable letter ballot of Committee D-1.[1]

A paper entitled "Method and Apparatus for Determining the Interval Required to Disperse Oil Colors Throughout a Paint Medium," by M. Rea Paul and George Diehlman, was presented by Mr. Paul and discussed.

Mr. R. L. Hallett then assumed the chair.

Mr. Hallett in introducing the Discussion on Tinting Strength reviewed briefly the work on this subject by Subcommittee VIII on Methods of Analysis of Paint Materials of Committee D-1 on Preservative Coatings for Structural Materials which prompted the committee to sponsor a public discussion on the tinting strength of white pigments and dry colors. The subject was introduced by the following papers which after presentation were discussed:

---

[1] This recommendation was submitted to letter ballot of Committee D-1 which consists of 173 members; 75 members returned their ballots, of whom 49 voted affirmatively and 5 negatively.

"A Discussion of the Accuracy and Utility of Methods of Test for Mass Tone and Tinting Strength of Dry Colors," by J. W. Ayers, presented by C. H. Love.

"Tinting Strength of White Pigments," by G. F. A. Stutz, presented by the author.

"Tinting Strength of White Pigments," by R. H. Sawyer, presented by the author.

The meeting then adjourned till the following morning.

THIRD SESSION—WEDNESDAY, JUNE 27, 9.30 A. M.

Steel, Wrought Iron, Cast Iron

(Held Simultaneously with Fourth Session)

Mr. A. E. White in the chair.

The report of Committee A-6 on Magnetic Properties was presented by the chair. The Tentative Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing (A 127 – 31 T), as revised, were approved for reference to letter ballot of the Society for adoption as standard.

The report of Committee A-9 on Ferro-Alloys was presented by the chairman, J. B. Gill. The proposed Method of Sampling Molybdenum Salts and Compounds for Metallurgical Use was accepted for publication as tentative. The Tentative Specifications for Ferromolybdenum (A 132 – 31 T), for Ferrotungsten (A 144 – 32 T), for Low-Carbon Ferromolybdenum (A 145 – 32 T), for Molybdenum Salts and Compounds (A 146 – 32 T) and Methods of Chemical Analysis of Ferrotungsten and Ferromolybdenum (A 104 – 32 T) were approved for reference to letter ballot of the Society for adoption as standard. The withdrawal of the Standard Specifications for Tungsten Powder (A 97 – 27) was approved.

The report of Committee A-1 on Steel was presented by the chairman, H. H. Morgan. The proposed Tentative Specifications for Class I Electric-Fusion-Welded Steel Pipe for High-Temperature and High-Pressure Service were accepted for publication as tentative. The proposed revisions of the Standard Specifications for Open-Hearth Carbon-Steel Rails (A 1 – 30), for Boiler Rivet Steel and Rivets (A 31 – 24), for Structural Rivet Steel (A 141 – 33), for Structural Steel for Ships (A 131 – 33), for Billet-Steel Concrete Reinforcement Bars (A 15 – 33), for Rail-Steel Concrete Reinforcement Bars (A 16 – 33), for Carbon-Steel Car and Tender Axles (A 21 – 27), for Wrought Solid Carbon-Steel Wheels for Electric Railway Service (A 25 – 24), for Welded and Seamless Steel Pipe (A 53 – 33), for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 33), for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 33), and for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 33) were accepted for publication as tentative.

The proposed revisions of the Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 32 T), for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139 – 32 T), for Cold-Rolled Strip Steel (A 109 – 27 T) and for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 33 T) were accepted, the specifications as revised being continued as tentative. The Tentative Specifications for Electric-Resistance-Welded Steel Pipe (A 135 – 32 T), for Lock-Bar Steel Pipe (A 137 – 32 T) and for Riveted Steel and Wrought-Iron Pipe (A 138 – 32 T) were approved for reference to letter ballot of the Society for adoption as standard. The Tentative Specifications for Forge-Welded Steel Pipe (A 136 – 32 T) were also approved for reference to letter ballot of the Society for adoption as standard with the following modification, presented on the floor at the annual meeting, subject to favorable letter ballot of Committee A-1:[1]

Section 8 (*b*).—Change the time specified for maintaining the test pressure in the hydrostatic test from the present requirement of not less than "5 sec" to read "30 sec."

The immediate adoption as standard of the Tentative Specifications for Steel for Bridges (A 7 – 33 T), for Steel for Buildings (A 9 – 33 T) and for Mild Steel Plates (A 10 – 33 T), the two former specifications to replace existing standards, was unanimously approved for reference to letter ballot of the Society, this recommendation requiring a nine-tenths vote. The tentative revisions of the Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 33) and for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 33) were approved for reference to letter ballot of the Society for adoption as standard.

The withdrawal of the Standard Specifications for Structural Steel for Bridges (A 7 – 33), and for Structural Steel for Buildings (A 9 – 33), and the Tentative Specifications for Electric Cast-Steel Stud-Link Anchor Chain (A 77 – 28 T) was approved.

It was announced that the committee had agreed on a revision of the Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 33), increasing the specified elongation in 2 in. for low-carbon seamless pipe from 30 per cent, minimum, to 35 per cent, minimum, this change to be submitted to the Society through Committee E-10 on Standards for publication as a tentative revision.

The Report of the Sectional Committee on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing was presented by the chairman, H. H. Morgan.

A paper entitled "Effect of Size and Shape of Test Specimen upon the Observed Physical Properties of Structural Steel," by Inge Lyse and C. C. Keyser, was presented by H. F. Moore and discussed.

A paper entitled "Testing Sheets for Blue Brittleness and Stability Against Changes Due to Aging," by R. L. Kenyon and R. S. Burns, was presented by Mr. Kenyon.

---

[1] The proposed revision was submitted to letter ballot of Committee A-1 which consists of 195 members; 78 members returned their ballots, of whom 52 voted affirmatively and none negatively.

The report of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel, comprising the following two subjects, was presented by the chairman, H. S. Rawdon, and discussed:

(*a*) Effect of Added Phosphorus on Low-Carbon Steel.
(*b*) Effect of Sulfur on Forging Steels.

The report of the joint committee was accepted for publication with the understanding that the section covering the effect of sulfur on forging steels would be clarified to bring out more definitely the limitations of the conclusions drawn.

The report of Committee A-2 on Wrought Iron was presented by the secretary, G. H. Woodroffe. The proposed revisions of the Standard Specifications for Hollow Rolled Staybolt Iron (A 86 – 30) and for Wrought-Iron Plates (A 42 – 30), the revision of the latter in the form of separate tentative specifications, were accepted for publication as tentative. The Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 32 T) were approved for reference to letter ballot of the Society for adoption as standard. Attention was called to the comprehensive report on Quality Standards for Wrought Iron prepared by a special subcommittee of Subcommittee X on Research and appended to the report of Committee A-2.

The report of Committee A-3 on Cast Iron was presented by the chairman, Hyman Bornstein. The proposed revision of the Tentative Specifications for Cast-Iron Culvert Pipe (A 142 – 32 T) was accepted, the specifications as revised being continued as tentative. Attention was called to the report of a Special Subcommittee on Test Bars reporting cooperative tests carried on in connection with the existing Tentative Specifications for Gray-Iron Castings (A 48 – 32 T).

An informal report of the Sectional Committee on Specifications for Cast-Iron Pipe and Special Castings was presented by J. T. MacKenzie.

The meeting then adjourned till 2 p. m.

FOURTH SESSION—WEDNESDAY, JUNE 27, 9.30 A. M.

Coal and Coke, Timber, Petroleum Products

(Held Simultaneously with Third Session)

President T. R. Lawson in the chair.

The report of Committee D-5 on Coal and Coke was presented by the chairman, A. C. Fieldner. The proposed Method of Test for Agglutinating Value of Coal, originally proposed as tentative in the report as preprinted, was recommended for publication as information and accepted. The editorial revision proposed in the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 – 33) was accepted. The recommendation appearing in the report as preprinted proposing the adoption as standard of the Tentative Definition of the Term Coke (D 121 – 30 T) was withdrawn, and it was announced that the definition will be referred back to Committee E-8 on Nomenclature and Definitions for further consideration. The tentative revision of the Standard Method of Test for Size of Anthracite (D 310 – 31), modified to read as follows was approved for reference to letter ballot of the Society for adoption as standard, subject to favorable letter ballot of Committee D-5:[1]

Section 3.—Change this section of the method to read as follows:

3. (*a*) The screen openings adopted by the Anthracite Institute, April 1, 1931, as specifications for the preparation of anthracite, are as follows:

SIZE	SIZE OF ROUND-HOLE OPENINGS IN TESTING SCREENS
Broken	Passing a $4\frac{3}{8}$-in. screen, retained on a $3\frac{1}{4}$-in. screen
Egg	Passing a $3\frac{1}{4}$-in. screen, retained on a $2\frac{7}{16}$-in. screen
Stove	Passing a $2\frac{7}{16}$-in. screen, retained on a $1\frac{5}{8}$-in. screen
Chestnut	Passing a $1\frac{5}{8}$-in. screen, retained on a $\frac{13}{16}$-in. screen
Pea	Passing a $\frac{13}{16}$-in. screen, retained on a $\frac{9}{16}$-in. screen
No. 1 Buckwheat	Passing a $\frac{9}{16}$-in. screen, retained on a $\frac{5}{16}$-in. screen
No. 2 Buckwheat (Rice)	Passing a $\frac{5}{16}$-in. screen, retained on a $\frac{3}{16}$-in. screen
No. 3 Buckwheat (Barley)	Passing a $\frac{3}{16}$-in. screen, retained on a $\frac{3}{32}$-in. screen

NOTE.—Tolerances of ± 3 per cent on average openings and of 10 per cent in maximum openings are permissible.

(*b*) When testing coal, therefore, to determine conformity with these specifications, these sizes of screen openings shall be used in the test.

The report of the Sectional Committee on Classification of Coals was presented by the chairman, A. C. Fieldner. The proposed Tentative Specifications for Classification of Coals by Grade, and the Specifications for Classification of Coals by Rank, including the names given to the classes and groups of coals, were accepted for publication as tentative.

An informal report of Committee C-5 on Fire Tests of Materials and Construction was presented by F. E. Emery.

The report of Committee D-7 on Timber was presented by the chairman, Hermann von Schrenk. The proposed Tentative Specifications for Creosote, and for Creosote Coal-Tar Solution were accepted for publication as tentative. The proposed revision of the Tentative Specifications for Timber Piles (D 25 – 30 T) was accepted, the specifications as revised being continued as tentative.

A paper entitled "Measuring the Combustibility of Fire-Retardant Wood," by E. F. Hartman, A. S. Williams and R. C. Bastress, was presented from manuscript by Mr. Williams and discussed.

Mr. T. G. Delbridge then assumed the chair.

The report of Committee D-2 on Petroleum Products and Lubricants was presented by the chairman, T. A. Boyd. The revisions proposed for immediate adoption in the Standard Methods of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil (D 129 – 33) and in the Abridged Volume Correction Table for Petroleum Oils (D 206 – 25) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The proposed revisions of the Standard Methods of Test for Dilution of Crankcase Oils (D 322 – 33), for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 – 30), for Precipitation Number of Lubricating Oils (D 91 – 33) and for Water and Sediment in Petroleum Products by Means of Centrifuge (D 96 – 30) were accepted for publication as tentative. The editorial revision of the Standard Method of Test for Distillation of Crude Petroleum (D 285 – 33) was accepted.

---

[1] The revision as modified was submitted to letter ballot of Committee D-5 which consists of 39 members; 39 members returned their ballots, of whom 32 voted affirmatively and none negatively.

The proposed revision of the Tentative Methods of Test for Color of Lubricating Oils by Means of A.S.T.M. Union Colorimeter (D 155 – 32 T), for Color of Petrolatum by Means of A.S.T.M. Union Colorimeter (D 218 – 32 T), for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (D 156 – 23 T) and for Sulfur in Motor Fuels, Naphthas and Illuminating Oils (Lamp Method) (D 90 – 30 T) were accepted, the methods as revised being continued as tentative. The tentative revision of the Standard Method of Test for Cloud and Pour Points (D 97 – 33), as revised, was approved for reference to letter ballot of the Society for adoption as standard.

The following minor revisions of the Standard Methods of Sampling Petroleum and Petroleum Products (D 270 – 33), presented on the floor at the annual meeting, were accepted as editorial changes subject to a favorable letter ballot of Committee D-2:[1]

Section 56.—In the note following this section change the third sentence to read as follows by the addition of the italicized words:

> Samples placed in glass bottles shall be kept in the dark if subsequent testing is to include color and sludge-forming characteristics or neutralization values *as light produces changes in these properties.*

Section 59.—In the note following Paragraph (*a*) of this section change the fifth sentence to read as follows by the omission of the words in brackets:

> Bottles or containers shall be so handled that the operator's fingers never touch the lip [, and a portion of the sample shall be poured over the lip and thrown away before pouring the sample into the testing apparatus].

Section 60.—Delete from this section the note which reads as follows:

> NOTE.—Instead of empty sample containers the operator may carry along containers filled with clean tested oil which may be poured into the top of the apparatus to compensate for the quantity removed.

The following proposed revisions of the Tentative Method of Test for Knock Characteristics of Motor Fuels (D 357 – 33 T), presented on the floor at the annual meeting, were accepted, subject to a favorable letter ballot of Committee D-2,[2] the method as revised to be continued as tentative.

Section 3.—Change Paragraphs (*l*), (*n*) and (*p*) of this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> (*l*) Oil Heater *and Thermometer.*—Electric heater in base to bring oil to operating temperature quickly, *and a thermometer on the instrument panel to indicate when equilibrium temperature has been reached.*
>
> (*n*) Carburetor[a]—A special C.F.R. carburetor is furnished with the engine, and can be obtained with either two or [four] *three* float bowls. The carburetor has a fixed fuel jet [shrouded by a variable air jet], *and*

---

[a] The use of knock testing apparatus equipped with the carburetor described in the 1933 edition of the method is permissible.

---

[1] The editorial revisions were submitted to letter ballot of Committee D-2 which consists of 84 members; 70 members returned their ballots, of whom 67 voted affirmatively and none negatively.

[2] The proposed revisions were submitted to letter ballot of Committee D-2 which consists of 84 members; 70 members returned their ballots, of whom 53 voted affirmatively and 1 negatively.

each float bowl is individually adjustable for level with respect to the jet for varying mixture ratio. Fuel containers are furnished with the carburetor.

(*p*) Instruments.—Knock intensity is measured by a bouncing pin, in conjunction with [either] a knockmeter [or a gas-evolution burette]. (The knockmeter is a damped hot-wire ammeter which indicates the effective current in the circuit, thus permitting instantaneous readings.) Current is supplied from a small direct-current generator, belt-driven from the power-absorbing unit. [The gas-evolution burette is an electrolytic cell which integrates the impulses of current through the bouncing-pin circuit and indicates the total by the volume of gas collected in the burette in a given time.]

Section 8.—Delete from the next to the last sentence of the first paragraph the phrase "or from the gas-evolution burette, whichever is used."

Change the first sentence of the second paragraph to read as follows by the addition of the italicized words and the omission of those in brackets:

For subsequent tests on fuel samples the compression ratio shall be set to duplicate [this] *the* knock intensity as [indicated by the knockmeter or the gas-evolution burette] *recorded above,* provided no change has been made in the bouncing-pin adjustment in the meantime.

Section 9.—Change the last sentence of the first paragraph to read as follows by the omission of the words in brackets; also delete the footnote:

The knock intensity shall be measured by the bouncing-pin indicator in conjunction with [either] a knockmeter [or a gas-evolution burette].

Section 10.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

10. Using the fuel whose knock rating is to be determined, the carburetor shall be adjusted as follows: After one float bowl of the carburetor has been filled with the fuel of which the octane number is to be determined, adjustment shall be made to obtain maximum knock by [noting the needle-valve micrometer-setting and the knockmeter reading or gas evolution, then turning the micrometer screw] *raising and lowering the level of the float bowl* and noting whether the knockmeter reading [or gas evolution] increases or decreases. The [micrometer] *float bowl* shall then be [turned] *moved* in the direction in which the knock increases until the knock passes through a maximum. This point shall be checked three times and the [micrometer] *float bowl* set at the position of maximum knock. [(*a*) By Knockmeter.—When using the knockmeter, it is unnecessary to take readings over a fixed period of time, but] The knockmeter needle shall be allowed to reach equilibrium after each adjustment of the [micrometer] *float-bowl* level.

[(*b*) By Gas-Evolution Burette.—At least two readings, agreeing within 5 per cent, of the volume of gas evolved over a period of 1 minute shall be taken as a measure of knock intensity.]

Section 11.—Delete the phrase "or the gas-evolution burette."

Section 12.—Change "micrometer" to "level" in the last sentence.

Section 13.—Change the first paragraph to read as follows by the omission of the words in brackets:

With the carburetor [micrometers] set for the air-fuel ratio of maximum knock, alternate series of readings of knock intensity shall be taken on the fuel under test and on a reference fuel blend. [When using] The knockmeter [the] needle shall be allowed to reach equilibrium before the final reading is recorded. [When using the gas-evolution burette, at least two successive 1-minute readings shall agree within 5 per cent.]

A proposed classification of Diesel fuel oils was accepted for publication in the report as information subject to a favorable letter ballot of Committee D-2.[1] It was announced that the committee had completed the preparation of proposed specifications for fuel oils which if approved by letter ballot of the committee would be presented to the Society for publication as tentative through Committee E-10 on Standards subsequent to the annual meeting.

Mr. Delbridge in introducing the Discussion on Vapor Lock reviewed briefly the consideration that had been given this subject by Technical Committee A on Gasoline of Committee D-2 on Petroleum Products and Lubricants. In view of certain recommendations under consideration in the technical committee as to specification limits and method of determining vapor lock a discussion of this important subject was believed desirable. The following two papers which were then presented were an outgrowth of the discussion of this subject in the committee:

"Motor Fuels and Vapor Lock," by George Granger Brown, presented by the author.

"Motors and Fuel Vapor Pressure," by T. A. Boyd, presented by the author.

Following their presentation the papers were discussed, the discussion being opened by R. C. Alden and Neil MacCoull.

The meeting then adjourned till 2 p. m.

FIFTH SESSION—WEDNESDAY, JUNE 27, 2.00 P. M.

Some Aspects of Specifying and Controlling Quality

Mr. Dean Harvey in the chair.

Mr. Harvey, in opening the session, referred briefly to the importance of the subject of this meeting and stated that it was arranged for the purpose of discussing certain aspects of the problems of specifying and controlling quality, particularly where quality can be measured only by sampling. Reference was made to the work of the Technical Committee on Interpretation and Presentation of Data of Committee E-1 on Methods of Testing which, during the past several years, has been giving attention to the application of statistical methods and quality control theory to problems of sampling and interpretation of data. Under the auspices of the committee arrangements were accordingly made for this discussion dealing with ways in which statistical methods are being employed to advantage in practical problems. The following two papers, the first discussing certain sampling clauses used in specifications to provide criteria for the acceptance or rejection of material, and the other outlining the advantages to both the consumer and the producer of the establishment of a quality control program in a manufacturing plant, were then presented:

---

[1] The proposed classification was submitted to letter ballot of Committee D-2 which consists of 84 members; 72 members returned their ballots, of whom 57 voted affirmatively and 7 negatively.

"Acceptance-Rejection Requirements in Specifications," by H. F. Dodge, presented by the author.

"Application of Statistical Methods to the Solution of Metallurgical Problems in the Steel Plant," by W. C. Chancellor, presented by the author.

The presentation of these papers was followed by discussion.

The meeting then adjourned till 4.30 p. m.

SIXTH SESSION—WEDNESDAY, JUNE 27, 4.30 P. M.

Edgar Marburg Lecture

President T. R. Lawson in the chair.

The President in opening the session devoted to the Edgar Marburg Lecture recalled the establishment of this memorial Lecture nine years ago to perpetuate the memory of the first Secretary-Treasurer of the Society, Edgar Marburg. The Lecture brings to the Society through authorities in engineering and the sciences valuable descriptions of outstanding developments in the engineering materials field. It also commemorates one whose ideals, vision and foresight at the time of organization of the Society has made it the forum for expositions contributing to the furthering of knowledge of engineering materials.

The President then introduced the ninth Edgar Marburg Lecturer, Dr. Sheppard T. Powell, Consulting Sanitary and Chemical Engineer, who chose as the subject of the lecture: "Water as an Engineering and Industrial Material." This was a timely and particularly appropriate subject, since the Society has recently recognized the importance of water as an engineering material by organizing a committee on water for industrial uses.

Doctor Powell pointed out in his lecture that waters used for industrial purposes were complex chemical solutions and not just a simple compound of hydrogen and oxygen and, just as any other engineering material, they required for their proper use definite specifications and accurate methods of sampling and analysis. The deleterious effect on health and on industrial processes of water containing minerals such as lead, zinc, fluorides, silver, nickel, manganese, etc., even though present only in minute amounts, was emphasized. The lecturer urged the development and use of precise methods sufficiently delicate to detect the presence of these minerals. As an illustration of the importance of constructive research in this field as a means of furthering our knowledge of water analysis, Doctor Powell described the studies of scale in boilers resulting from mineral deposits at high temperatures and pressures which led to the development of a petrographic method of analysis. By this method in which thin sections of boiler scale are examined microscopically in plane polarized light it is possible to identify a mineral by the color, shape, index of refraction, etc., of its crystals. The method has revealed crystalline forms not previously identified. The lecturer, in describing this method of microanalysis and other recently developed procedures for analyzing waters and their mineral deposits including the spectrographic and polarographic methods, indicated they forecast the solution of many problems now unsolvable in the critical study of water as an engineering material.

President Lawson in expressing appreciation to Doctor Powell for his interesting and instructive lecture on a subject of direct interest to the Society presented to him on behalf of the Society, the Edgar Marburg Lecture Certificate.

The meeting then adjourned till 8.30 p. m.

SEVENTH SESSION—WEDNESDAY, JUNE 27, 8.30 P. M.

Presidential Address, Award of Dudley Medal

Past-President Cloyd M. Chapman in the chair.

The chairman presented President T. R. Lawson who delivered the annual Presidential Address in which he reviewed the growth of the Society since its inception in 1898 as the American Section of the International Association for Testing Materials and its subsequent incorporation in 1902 as the American Society for Testing Materials. The organization of a total of 77 standing, research, joint, and sectional committees, an active committee membership of approximately 1400, a Society membership of over 3500, the promulgation of 690 standards and tentative standards, and the increase in size and sales of Society publications annually were pointed to as indexes of its growth, which at the same time indicate the important position the Society occupies as a national organization serving science and industry through the continued advancement of knowledge of materials of engineering and their standardization. He pointed out that the Society is prepared and will be called upon in the future to keep its standards abreast of new developments and to expand its work further as new materials resulting from scientific research are introduced. In view of this continual increase and constant growth of Society activities, he advocated the consolidation, where possible, of standardization work, the furthering of co-operative relations with other societies and associations and the completion of plans for aiding materially the research work of the Society.

The chairman then recognized C. H. Mathewson, of the Committee on Award of the Charles B. Dudley Medal. Mr. Mathewson in presenting to the President as the recipient of the 1934 Award of the Dudley Medal, Mr. R. L. Templin for his paper on "The Fatigue Properties of Light Metals and Alloys," presented at the 1933 annual meeting of the Society, made the following remarks:

> "Mr. Chairman, President Lawson, ladies and gentlemen: I believe the Committee on the 1934 award of the Charles B. Dudley Medal felt a special satisfaction that the paper rated highest this year was a contribution from one whose position of influence and authority in the field of metal testing is so well understood everywhere that a list of the leaders in this field could not fail to include Mr. R. L. Templin, the Aluminum Company's brilliant Engineer of Tests, who is now introduced and presented for this honor. For fifteen years, almost his entire professional career, he has been with the Aluminum Company and during this period, through professional contacts, publications, committee activities and scientific discussion, he has made the Aluminum Company's establishment a fountain head of information and authority in metal testing. Lately, in presenting a colleague for promotion at Yale, I remarked that he was not a prolific

writer in the technology of his field but averaged about one important and substantial publication per year. Mr. Templin, also, writes not to fill pages but to record some of the technological experiences which flow continuously through his laboratory, and he has something of importance for us at every colloquium.

If you are interested in biographical details I should say that Mr. Templin was graduated from the University of Kansas in 1915 as B.S. in C.E., was a Research Fellow at the University of Illinois in 1915–17, where he received the M.S. degree in Theoretical and Applied Mechanics in 1917, and was awarded the Professional Degree of Mechanical Engineer at Kansas in 1925. Following his graduation in 1917 he spent two years at the National Bureau of Standards as engineering physicist.

It would take much time to recite the many items of practical experience which he fitted into his summers and spare time.

You who have read his 1933 paper, "The Fatigue Properties of Light Metals and Alloys," must have recognized it as outstanding in several respects: First, it covers the field of fatigue properties of commercial aluminum and magnesium alloys thoroughly and, on the basis of tests run 500,000,000 cycles, gives us a survey of fatigue properties of the aluminum-base alloys which is more complete and satisfying than anything heretofore produced in the case of any non-ferrous metal or alloy type.

One is appalled by the vast amount of work involved and the time which must have been spent in accumulating these results. For example, if one should attempt to run duplicate samples of Mr. Templin's 64 different alloys and tempers on one machine at the highest speed he used, 3500 r.p.m., it would take 35 years to test at one stress and one man would not live long enough to run tests at several different stress values. Of course, Mr. Templin and his associates did not do it this way; for multiplicity of machines and diversity of types, some of them of original design, his laboratory is the envy of every testing engineer.

Again, the work bears evidence of care and good judgment at every point—we commend it to you as an example of a comprehensive, precise and matured testing program from which safe and adequate conclusions can be drawn for the guidance of all who work with these materials.

I have the honor to present Mr. R. L. Templin for the 1934 award."

On behalf of and as the representative of the Society, President Lawson then made the Eighth Award of the Charles B. Dudley Medal to Mr. Templin. In accepting the medal Mr. Templin expressed his appreciation of the award as follows:

> "Mr. President, members of the American Society for Testing Materials: In expressing my appreciation of the award of the Charles B. Dudley medal, I should like to acknowledge the hearty cooperation and material assistance given me by members of the staff of the Aluminum Research Laboratories and the management of the Aluminum Company of America for the work covered by my paper of last year. I also wish to acknowledge the many helpful suggestions and ideas from co-workers in the field, especially those on the Research Committee on Fatigue of Metals, with whom I have been associated. I assure you I will cherish this token for the rest of my life. Thank you."

The chairman then recognized H. F. Moore, chairman of the Committee of Tellers, who reported the results of the letter ballot on election of officers. Of the 710 ballots cast, the results were as follows:

For President, to serve for one year: W. H. Bassett, 710 votes.
For Vice-President, to serve for two years: H. S. Vassar, 710 votes.
For Members of Executive Committee, to serve for two years:
  H. A. Anderson, 703 votes.
  H. J. Ball, 703 votes.
  W. M. Barr, 702 votes.
  L. S. Marsh, 703 votes.
  J. B. Rather, 703 votes.

In the absence of President-Elect W. H. Bassett, who was prevented by illness from attending the annual meeting, Past-President G. H. Clamer, acting for the President-Elect, was escorted to the chair by Past-Presidents A. N. Talbot and W. H. Fulweiler. On behalf of the President-Elect, Mr. Clamer stated that Mr. Bassett had eagerly anticipated the pleasure of receiving and acknowledging in person the honor that had been conferred upon him by the Society in the election to the Presidency. He then read the following letter from the President-Elect:

Waterbury, Conn., June 18, 1934

MR. T. R. LAWSON, President, A.S.T.M.,
Rensselaer Polytechnic Institute,
Troy, New York

My dear President Lawson:

I regret exceedingly being obliged to miss the Annual Meeting of the Society which I believe is only the second that I have failed to attend since I became a member. However, this is particularly unfortunate since the Society has honored me by electing me to succeed you as its president. I very sincerely appreciate this honor but I also appreciate that the spirit of the Society is accomplishment as well as loyalty and good fellowship among its members, so I feel that I should be with you and accept from your hands the duties and endeavors which you have to pass over at this time.

Please say to the officers and members that I am very grateful to them for their confidence and expect to be ready to take up the work as soon as the summer is over.

I hope, at least in progress and enthusiasm, that this will be the most successful meeting the Society has ever held and that we are looking forward to a year of advance in everything that means progress for the American Society for Testing Materials.

Kindly express to the members my most cordial greetings and very best wishes.

Very sincerely yours,

(Signed) W. H. BASSETT

The following telegram was then sent to Mr. Bassett extending the best wishes of the Society membership for his early and complete recovery:

MR. W. H. BASSETT,
CHESHIRE, CONN.

THE MEMBERS OF THE AMERICAN SOCIETY FOR TESTING MATERIALS ASSEMBLED AT THE SEVENTH SESSION OF THE THIRTY-SEVENTH ANNUAL MEETING HAVE RECEIVED WITH GREAT JOY AND SATISFACTION THE REPORT OF THE TELLERS ADVISING OF YOUR ELECTION TO THE PRESIDENCY OF OUR SOCIETY. WE ARE VERY HAPPY INDEED TO HAVE AS OUR PRESIDENT FOR THE ENSUING YEAR A MEMBER WHO HAS SO WELL EARNED THROUGH LONG, FAITHFUL, INTELLIGENT AND UNTIRING SERVICE TO THE SOCIETY HIS RIGHT TO THAT DISTINGUISHED RECOGNITION. WE ARE GRATIFIED ALSO THAT THE SOCIETY SHALL HAVE THE ADVANTAGE OF YOUR ABLE GUIDANCE. WE GREATLY MISS THE OPPORTUNITY OF THE ALWAYS PLEASANT PERSONAL CONTACT THAT WE HAVE HAD WITH YOU DURING SO MANY ANNUAL CONVENTIONS IN THE PAST AND SEND TO YOU OUR ESTEEM AND BEST WISHES FOR A SPEEDY RECOVERY.

AMERICAN SOCIETY FOR TESTING MATERIALS
IN ANNUAL MEETING ASSEMBLED

At the request of the chairman, Vice-President Hermann von Schrenk escorted the Vice-President-Elect, H. S. Vassar, to the chair. Mr. Vassar expressed his appreciation of the honor of being elected to the office of Vice-President. He stated that he realized the acceptance of that office carries with it certain responsibilities which he was ready to accept and that he would endeavor at all times to perform such duties in the best interests of the Society.

The chairman then presented the newly elected members of the Executive Committee.

The meeting then adjourned till the following morning and was followed by the annual dance and smoker. An informal reception to the new officers and members of the Executive Committee was held immediately after the adjournment of the meeting.

EIGHTH SESSION—THURSDAY, JUNE 28, 9.30 A. M.

Effect of Temperature on Metals, Fatigue of Metals

(Held Simultaneously with Ninth Session)

Mr. J. T. MacKenzie in the chair.

The report of the Joint Research Committee of A.S.M.E. and A.S.T.M. on Effect of Temperature on the Properties of Metals was presented from manuscript by the chairman, H. J. French. In presenting the report Mr. French called upon A. E. White to describe the proposed revisions in the existing Tentative Methods of Test for Short-Time High-Temperature Tension Tests of Metallic Materials (E 21 - 33 T) and for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials (E 22 - 33 T) which the committee had approved and which would be presented to the Society through Committee E-10 on Standards subsequent to the annual meeting.

A paper entitled "The Interpretation of Creep Tests," by P. G. McVetty was presented by the author and discussed.

A paper entitled "Creep Properties of 5 per cent Chromium and ½ per cent Molybdenum Steel Still Tubes," by H. C. Cross and E. R. Johnson was presented from manuscript by Mr. Cross and discussed.

A paper entitled "Aging Embrittlement of 4 to 6 per cent Chromium Steel," by H. M. Wilten and E. S. Dixon was presented from manuscript by Mr. Dixon and discussed.

The report of the Research Committee on Fatigue of Metals was presented by the chairman, H. F. Moore.

A paper entitled "A High-Speed Fatigue Testing Machine and Some Tests of Speed Effect on Endurance Limit," by G. N. Krouse was presented by the author and discussed.

The meeting then adjourned till 8 p. m.

NINTH SESSION—THURSDAY, JUNE 28, 9.30 A. M.

Waterproofing and Road Materials

(Held Simultaneously with Eighth Session)

Past-President K. G. Mackenzie in the chair.

The report of Committee D-8 on Bituminous Waterproofing and Roofing Materials was presented by the chairman, J. M. Weiss. The Tentative Method of Analysis of Roofing Felt for Fiber Composition (D 272 – 29 T) was approved for reference to letter ballot of the Society for adoption as standard. It was announced that the four proposed revised tentative specifications for asphalt roofing and the methods of test for bituminous emulsions used for waterproofing, which appeared in the preprinted report as information, would be submitted to the Society for publication as tentative through Committee E-10 on Standards subsequent to the annual meeting.

A paper entitled "Bituminous Joint Compounds for Sewer Pipe," by J. S. Crandell was presented by the author and discussed.

A paper entitled "Indentation of Asphalt Tile," by J. W. McBurney was presented by the author and discussed.

The report of Committee D-4 on Road and Paving Materials was presented by M. H. Ulman. The Tentative Specifications for Calcium Chloride (D 98 – 33 T), as revised, and the Tentative Methods of Chemical Analysis of Calcium Chloride (D 345 – 32 T) were approved for reference to letter ballot of the Society for adoption as standard. It was announced that the proposed method of test for distillation of liquid asphaltic products, the five new proposed specifications for emulsified asphalt and an extensive revision of the existing Tentative Methods of Test for Emulsified Asphalt for Use on Roads (D 244 – 33 T) which appeared in the preprinted report as information would be submitted to the

Society for publication as tentative through Committee E-10 on Standards subsequent to the annual meeting.

The chairman then introduced Mr. J. B. Rather, who called attention to the contribution made by Committee D-4 in preparing sections relating to methods of test for bituminous materials of petroleum origin for inclusion in the Report on Significance of Tests of Petroleum Products prepared by Committee D-2 on Petroleum Products and Lubricants.

The chairman then introduced Mr. C. N. Forrest, who assumed the chair.

A paper entitled "Subgrade Soil Testing Methods," by C. A. Hogentogler and E. A. Willis was presented from manuscript by Mr. Hogentogler and discussed.

A paper entitled "A Laboratory Service Test for Pavement Materials," by A. T. Goldbeck, J. E. Gray and L. L. Ludlow, Jr., was presented by Mr. Goldbeck and discussed.

The meeting then adjourned till 8 p. m.

TENTH SESSION—THURSDAY, JUNE 28, 8 P. M.

Corrosion

(Held Simultaneously with Eleventh Session)

Mr. W. H. Finkeldey in the chair.

The report of Committee A-10 was presented by the chairman, Jerome Strauss. It was announced that the proposed Specifications for Welded Corrosion-Resistant Articles Made from Austenitic Chromium-Nickel Steel, appearing in the report as preprinted, had been withdrawn by the committee for further study. In presenting the report Mr. Strauss called attention to a study of the metallographic treatment of alloys with which the committee has been dealing as described in a paper appended to the report by J. R. Vilella entitled "The Polishing and Etching of Iron-Chromium and Iron-Chromium-Nickel Alloys."

The report of Committee A-5 on Corrosion of Iron and Steel was presented from manuscript by the acting chairman, H. E. Smith. In presenting the report Mr. Smith called upon R. F. Passano to describe the work of Subcommittee VIII on Field Tests of Metallic Coatings. The report was accepted for publication subject to favorable letter ballot of Committee A-5.[1]

A paper entitled "The Use of Bureau of Standards Soil Corrosion Data in the Design and Protection of Pipe Lines," by K. H. Logan was presented by the author and discussed. Attention was called to the fact that the information made available by these soil corrosion studies constitute a most valuable contribution to present knowledge concerning pipe corrosion and were of considerable public interest. On motion it was voted to bring this matter to the attention of the Executive Committee of the Society and urge the continuation and expansion of this work by the National Bureau of Standards.

---

[1] The report was submitted to letter ballot of Committee A-5 which consists of 127 members; 60 members returned their ballots, of whom 58 voted affirmatively and none negatively.

A paper entitled "Observations on Effect of Surface Finish on the Initial Corrosion of Steel Under Water," by L. J. Waldron and E. C. Groesbeck was presented by W. H. Swanger and discussed.

The report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys was presented from manuscript by the chairman, T. S. Fuller. In presenting the report Mr. Fuller called upon R. J. McKay to describe the work of Subcommittee VII on Corrosion in Liquids and on C. L. Hippensteel to present the report of Subcommittee VIII on Galvanic and Electrolytic Corrosion. The report was accepted for publication subject to favorable letter ballot of Committee B-3.[1]

A paper entitled "The Determination of Traces of Dissolved Oxygen by the Winkler Method," by N. C. Schwartz and W. B. Gurney was presented by W. C. Schroeder and discussed.

The report of Committee D-19 on Water for Industrial Uses was presented by F. N. Speller.

The meeting then adjourned till the following morning.

ELEVENTH SESSION—THURSDAY, JUNE 28, 8 P. M.

Rubber, Textiles, Electrical Insulating Materials

(Held Simultaneously with Tenth Session)

Mr. H. S. Vassar in the chair.

The report of Committee D-13 on Textile Materials was presented by the chairman, H. J. Ball. The revisions proposed for immediate adoption in the Standard Specifications for Chafer Tire Fabrics (D 316 – 33) and in the General Methods of Testing Woven Textile Fabrics (D 39 – 27) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. The proposed revisions of the Tentative Definitions of Terms Relating to Textile Materials (D 123 – 33 T) and Specifications for Holland Cloth (D 376 – 33 T) were accepted, the definitions and specifications as revised being continued as tentative. The Tentative Specifications for 0.007-in. Cotton Tape (D 335 – 31 T) and Method of Determining Relative Humidity (D 337 – 31 T) were approved for reference to letter ballot of the Society for adoption as standard. A recommendation for the adoption as standard of the Tentative Specifications and Test Methods for Rubber and Pyroxylin Coating (D 334 – 31 T), presented on the floor at the annual meeting, was unanimously accepted for reference to letter ballot of the Society for adoption. The tentative revisions of the Standard Specifications for Tolerances for Hose Ducks and Belt Ducks (D 181 – 33) and for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (D 274 – 29) and General Methods of Testing Woven Textile Fabrics (D 39 – 27) were approved for reference to letter ballot of the Society for adoption as standard.

The report of Committee D-11 on Rubber Products was presented by the chairman, H. A. Depew. The proposed Tentative Methods of Test for Abrasion

---

[1] The report was submitted to letter ballot of Committee B-3 which consists of 51 members; 30 members returned their ballots, of whom 26 voted affirmatively and 4 negatively.

Resistance of Rubber Compounds, Test for Compression Set of Rubber Used for Vibration Absorption and Specifications for Insulated Wire and Cable: Class A, 30 per cent Hevea Rubber Compound were accepted for publication as tentative. The proposed revisions of the Tentative Specifications for Insulated Wire and Cable: 30 per cent Hevea Rubber (D 27 – 33 T) and for Friction Tape for General Use for Electrical Purposes (D 69 – 32 T) were accepted, the specifications as revised being continued as tentative. The Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public and Private Fire Department Use (D 296 – 31 T) and Method of Test for Hardness of Rubber (D 314 – 31 T) were approved for reference to letter ballot of the Society for adoption as standard. It was announced that the recommendation appearing in the report as preprinted for the adoption as standard of the Tentative Specifications for Rubber Pump Valves (D 151 – 31 T) had been withdrawn by the committee. The proposed Specifications for Rubber Insulating Blankets for Use Around Electrical Apparatus or Circuits not Exceeding 3000 Volts to Ground were accepted for publication as information. In presenting the report Mr. Depew announced that the committee had accepted a paper by A. H. Flower and H. E. Wening entitled "Proposed Method for Testing the Adhesion of Rubber to Metal," for publication with its annual report, subject to the approval of Committee E-6 on Papers and Publications. Mr. Depew then introduced Mr. Flower who presented the paper from manuscript, following which it was accepted for publication.

It was announced that the committee had completed a revision of the existing Tentative Specifications for Rubber Insulating Tape (D 119 – 32 T), the Tentative Specifications for Insulated Wire and Cable: Performance Rubber Compound (D 353 – 33 T), and also further changes in the revised Tentative Specifications for Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (D 27 – 33 T) and in the Tentative Methods of Test for Abrasion Resistance of Rubber Compounds which would be presented to the Society through Committee E-10 on Standards subsequent to the annual meeting.

A paper entitled "The Testing of Rubber and Rubber-Like Materials for Oil Resistance," by O. M. Hayden was presented by the author and discussed.

A paper entitled "Materials for Use in Structural Engineering Models, with Special Reference to Rubber Compounds," by A. V. Karpov was presented from manuscript by R. L. Templin.

A paper entitled "The Testing of Raw Materials for Rubber Compounds," by B. S. Taylor was presented by the author and discussed.

The report of Committee D-9 on Electrical Insulating Materials was presented by the chairman, H. L. Curtis. The proposed Methods of Test for Molding Powders Used in Electrical Insulation were accepted for publication as tentative. The proposed revisions of the Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 33) were accepted for publication as tentative. The tentative revisions of the Standard Methods of Testing Electrical Porcelain (D 116 – 30) were approved for reference to letter ballot of the Society for adoption as standard. The proposed revisions of the Tentative Methods of Testing Varnishes Used for Electrical Insulation (D 115 – 31 T), Sheet and Tape Insulating Materials for Dielectric Strength (D 149 – 33 T), Electrical Insulating Materials for Power Factor and Dielectric Constant

(D 150 – 32 T), Compounds Used for Splicing Electrical Cables and Filling Potheads (D 176 – 33 T), Untreated Paper Used in Electrical Insulation (D 202 – 33 T), Laminated Sheet Materials Used in Electrical Insulation (D 229 – 32 T), Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 – 33 T), Laminated Tubes Used in Electrical Insulation (D 348 – 32 T), Laminated Round Rods Used in Electrical Insulation (D 349 – 32 T), and Sheet and Tape Electrical Insulation for Thickness (D 374 – 33 T) and Specifications for Black Bias-Cut Varnished Cloth Tape Used for Electrical Insulation (D 373 – 33 T) were accepted, the methods and specifications as revised being continued as tentative. It was announced that the committee had developed additional revisions in certain of the methods under its jurisdiction and that these would be submitted to the Society through Committee E-10 on Standards subsequent to the annual meeting.

A paper entitled "A Comparison of the Methods for Testing Insulating Materials for Power Factor and Dielectric Constant at 1000 Cycles," by W. B. Kouwenhoven and L. W. Marks was presented by Mr. Marks and discussed.

An informal report of the Sectional Committee on Electrical Insulating Materials was presented by the chairman, H. L. Curtis.

The meeting then adjourned till the following morning.

TWELFTH SESSION—FRIDAY, JUNE 29, 9.30 A. M.

Non-Ferrous Metals, Metallography

(Held Simultaneously with Thirteenth Session)

Past-President G. H. Clamer in the chair.

The report of Committee B-2 on Non-Ferrous Metals and Alloys was presented by the secretary, E. E. Thum. It was announced that the committee had completed a proposed revision of the Standard Specifications for Pig Lead (B 29 – 23) which after favorable letter ballot by Committee B-2 would be presented to the Society for publication as tentative through Committee E-10 on Standards subsequent to the annual meeting.

A paper entitled "Some Factors Affecting Strain Measurements in Tests of Metals," by R. L. Templin was presented by the author and discussed.

The report of Committee B-6 on Die-Cast Metals and Alloys was presented by the chairman, H. A. Anderson. The proposed Tentative Specifications for Magnesium-Base Alloy Die Castings were accepted for publication as tentative. It was announced that the committee had completed a proposed revision of the Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 – 33 T) which would be presented to the Society through Committee E-10 on Standards subsequent to the annual meeting. In presenting the report Mr. Anderson called upon Mr. W. M. Peirce to present the report of Subcommittee V on Exposure and Corrosion Tests. A paper appended to the report entitled "The Effect of Variations in Aluminum Content on the Strength and Permanence of the A.S.T.M. No. XXIII Zinc Die Casting Alloy," by E. A. Anderson and G. L. Werley was then presented by Mr. Anderson and discussed.

A paper entitled "The Impact Strength of Commercial Zinc Die Castings," by E. A. Anderson and G. L. Werley was presented from manuscript by Mr. Anderson and discussed.

The report of Committee B-7 on Light Metals and Alloys, Cast and Wrought, was presented by the vice-chairman, Sam Tour. The proposed Tentative Specifications for Magnesium-Base Alloy Ingot for Remelting were accepted for publication as tentative. The proposed revisions of the Tentative Specifications for Aluminum Sheet and Plate (B 25 – 33 T), for Aluminum-Manganese Alloy Sheet and Plate (B 79 – 33 T), for Magnesium-Base Alloy Castings (B 80 – 31 T), for Magnesium-Base Alloy Sheet (B 90 – 32 T) and for Magnesium-Base Alloy Wrought Shapes (Other than Sheet) (B 91 – 32 T) were accepted, the specifications as revised being continued as tentative. In presenting the report Mr. Tour called upon E. H. Dix, Jr., who presented from manuscript a comprehensive report on "Service Characteristics of the Light Metals and Their Alloys," prepared by Subcommittee VII on Service Characteristics of Light Metals and Methods of Protection Against Corrosion, which was accepted for publication subject to favorable letter ballot of Committee B-7.[1]

The report of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys was presented by the chairman, Dean Harvey. The proposed Tentative Method of Test for Linear Expansion of Metals was accepted for publication as tentative. The proposed revision of the Tentative Methods of Chemical Analysis of Metallic Materials for Electrical Heating (B 71 – 33 T) was accepted, the methods as revised being continued as tentative. The Tentative Specifications for Drawn or Rolled Alloy, 80 per cent Nickel, 20 per cent Chromium, for Electrical Heating Elements (B 82 – 31 T), and for Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, and Balance Iron, for Electrical Heating Elements (B 83 – 31 T) and Method of Test for Determining the Temperature-Resistance Constants of Resistance Alloys (B 84 – 31 T) were approved for reference to letter ballot of the Society for adoption as standard.

The report of Committee E-4 on Metallography was presented by the chairman, C. H. Davis. It was announced that the committee had approved additional magnifications for inclusion in the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (E 2 – 30) referred to in the report. This revision will be presented to the Society for publication as tentative through Committee E-10 on Standards subsequent to the annual meeting.

A paper entitled "Note on Frictional Resistance of Steel and Brass in Shrink Fits," by W. H. Swanger was presented by the author and discussed.

The meeting then adjourned till 2 p. m.

---

[1] The report was submitted to letter ballot of Committee B-7 which consists of 33 members; 17 members returned their ballots, all of whom voted affirmatively.

THIRTEENTH SESSION—FRIDAY, JUNE 29, 9.30 A. M.

Ceramics, Refractories, Masonry Materials

(Held Simultaneously with Twelfth Session)

President T. R. Lawson in the chair.

The report of Committee C-3 on Brick was presented by the chairman, H. T. Shelley. The Tentative Specifications for Concrete Building Brick (C 55 - 33 T) were approved for reference to letter ballot of the Society for adoption as standard.

An informal report of Committee C-10 on Hollow Masonry Building Units was presented by the Secretary, F. E. Emery. It was announced that the committee had completed revisions of the existing Tentative Specifications for Structural Clay Load-Bearing Wall Tile (C 34 - 33 T), for Structural Clay Non-Load-Bearing Tile (C 56 - 33 T), for Structural Clay Floor Tile (C 57 - 33 T) and Definitions of Terms Relating to Structural Clay Tile (C 43 - 33 T) which had been issued in 1933 as tentative revisions of the existing standards, the withdrawal of which standards will be recommended by the committee. The committee has also completed a revision of the Tentative Specifications and Tests for Load-Bearing Concrete Masonry Units (C 90 - 33 T). These several recommendations are to be presented to the Society through Committee E-10 on Standards subsequent to the annual meeting.

A paper entitled "Tests on Reinforced Brick Masonry Columns," by M. O. Withey was presented by the author and discussed.

A paper entitled "Permeability Tests of 8-in. Brick Wallettes," by L. A. Palmer and D. A. Parsons was presented by Mr. Palmer and discussed.

A paper entitled "Resultant Separation Cracking Between Various Mortars and Brick in Existing Brick Structures," by C. C. Conner was presented by the author and discussed.

President Lawson then introduced Mr. M. O. Withey who assumed the chair.

A paper entitled "The Effect of De-Airing Dry-Press and Stiff-Mud Bodies for Clay Products Manufacture," by W. C. Rueckel and R. B. Keplinger was presented from manuscript by Mr. Rueckel and discussed.

The report of Committee C-8 on Refractories was presented by J. R. Dwyer. The proposed Tentative Specifications for Ground Fire Clay, for Refractories for Construction of Incinerators, Methods of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling, of Panel Test for Resistance to Thermal and Structural Spalling of Fire-Clay Brick for Stationary Boilers and Malleable Iron Furnace Bungs, of Chemical Analysis of Magnesite Refractories, Symbols for Heat Transmission, and Definitions of Terms Relating to Refractories, were accepted for publication as tentative. The proposed revisions of the Tentative Methods of Testing High-Temperature Heat Insulation (Compression, Flexure, Shrinkage) (C 93 - 33 T) were accepted, the methods as revised being continued as tentative. The withdrawal of the

Tentative Method of Control Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (C 38 – 33 T) and Definitions of Terms Relating to Heat Transmission of Refractories (C 71 – 31 T) was approved. The recommendation for the adoption as standard of the Tentative Method of Test for Particle Size of Ground Refractory Materials (C 92 – 32 T) appearing in the report as preprinted was referred back to Committee C-8 on Refractories in view of certain objections that had been raised.

The meeting then adjourned till 2 p. m.

FOURTEENTH SESSION—FRIDAY, JUNE 29, 2 P. M.

Cement, Lime, Gypsum

Past-President Cloyd M. Chapman in the chair.

The report of Committee C-11 on Gypsum was presented by the chair. The Tentative Specifications for Gypsum Wall Board (C 36 – 31 T), for Gypsum Lath (C 37 – 31 T) and for Gypsum Sheathing Board (C 79 – 31 T), were approved for reference to letter ballot of the Society for adoption as standard.

The report of Committee C-7 on Lime was presented by the chairman, J. R. Withrow. The proposed revisions of the Standard Specifications for Quicklime for Structural Purposes (C 5 – 26), for Hydrated Lime for Structural Purposes (C 6 – 31) in the form of new tentative specifications and new Tentative Methods of Physical Tests for Limestone, Quicklime and Hydrated Lime were accepted for publication as tentative. The withdrawal of the tentative revision of the Standard Specifications for Hydrated Lime for Structural Purposes (C 6 – 31) was approved.

It was announced that an informal progress report of the Sectional Committee on Specifications for Plastering would be submitted to the Executive Committee by the acting chairman, F. Leo Smith, subsequent to the annual meeting.

The report of Committee C-1 on Cement was presented by the chairman, P. H. Bates. In presenting the report Mr. Bates summarized the work being carried on by the committee which was described in detail in the annual report. The proposed Tentative Method of Test for Compressive Strength of Portland Cement Mortars was acepted for publication as tentative with the following modifications, presented on the floor at the annual meeting, subject to favorable letter ballot of Committee C-1:[1]

Section 3.—After the words "B 55 Rockwell Number" add in parenthesis the corresponding Brinell hardness number as follows: "(Brinell number 95)."

Section 4.—Change this section from the form as preprinted to read as follows:

> 4. (*a*) The testing machine for determination of the compressive strength may be either the hydraulic or the screw-type with sufficient opening between the upper bearing surface and the lower bearing surface of the machine to permit the use of verifying apparatus. The load applied to the test specimen shall be indicated with an accuracy of ± 1.0 per cent.

---

[1] The proposed revisions were submitted to letter ballot of Committee C-1 which consists of 69 voting members; 59 members returned their ballots, of whom 54 voted affirmatively and 2 negatively.

(*b*) The upper bearing shall be a spherically seated, hardened, metal block firmly attached at the center of the upper head of the machine. The center of the sphere shall lie at the center of the surface of the block in contact with the specimen. The block shall be closely held in its spherical seat, but shall be free to turn in any direction. The diagonal or diameter[a] of the bearing surface shall be only slightly greater than the diagonal of the face of the 2-in. cube in order to facilitate accurate centering of the specimen. A hardened metal bearing block shall be used beneath the specimen to minimize wear of the lower platen of the machine. The bearing block surfaces intended for contact with the specimen should have a hardness not less than C 60 Rockwell number (Brinell number 620). These surfaces shall not depart from plane surfaces by more than 0.0005 in. when the blocks are new and shall be maintained within a tolerance of 0.001 in.

---

[a] A diameter of 3⅛ in. is satisfactory and is large enough for testing 3 by 6-in. cylinders.

Section 9.—Change the temperature "250 F." to read "248 F."

Section 10.—Change the heading of this section to read "Proportioning and Mixing of Mortars" and add the following as a new first paragraph:

The mortar shall consist of 1 part cement to 2.77 parts graded Ottawa sand by weight and 53 per cent water by weight of cement (water-cement ratio of 0.8 by volume).

Section 14.—Change this section from the form as preprinted to read as follows:

14. The cube shall be carefully placed in the testing machine below the center of the upper bearing block. No cushioning or bedding materials shall be used. An initial load of not more than 50 per cent (25 per cent for low-heat portland cements at ages of 7 days or less) of the expected maximum load shall be applied at any convenient rate, after which the specimen shall be loaded continuously to failure at a rate or rates which shall at no time be less than 1000 nor more than 6000 lb. per sq. in. per minute.[b]

---

[b] While the data presented in the report of the 1933 cooperative tests do not give conclusive evidence on effect of rate of loading, the Working Committee on Plastic Mortar Tests favors the use of a uniform rate of loading of about 4000 lb. per sq. in. per minute (1000 lb. per sq. in. per minute for low-heat portland cements at ages of 7 days or less).

Explanatory Note.—Delete Note 1, which reads as follows, in the method as preprinted, and renumber the remaining notes accordingly:

NOTE 1.—*Dial Capacities and Graduations for Testing Machines:* The following dial capacities and graduations are recommended for the various ranges of strength of specimens:

DIAL CAPACITY, LB.	RANGE OF USE, LB.	DIAL GRADUATION, LB.
0 to 2 000	200 to 2 000	5
0 to 10 000	1000 to 10 000	20
0 to 50 000	5000 to 50 000	100

In the renumbered Note 1 add "Ottawa" between the words "graded sand."

A paper entitled "Study of Cement Composition in Relation to Strength, Length Changes, Resistance to Sulfate Waters, and to Freezing and Thawing of Mortars and Concrete," by H. F. Gonnerman was presented from manuscript by the author and discussed.

A paper entitled "The Suspension Turbidimeter for Determination of Specific Surface of Granular Materials," by Alexander Klein was presented by R. E. Davis and discussed.

A paper entitled "The Vane Calorimeter," by R. W. Carlson was presented from manuscript by the author and discussed.

The meeting then adjourned till 8 p. m.

FIFTEENTH SESSION—FRIDAY, JUNE 29, 8 P. M.

Concrete

Mr. F. E. Richart in the chair.

The report of Committee C-9 on Concrete and Concrete Aggregates was presented by the chairman, R. W. Crum. The proposed Tentative Specifications for Sodium Silicate for Curing Concrete were accepted for publication as tentative with the following modifications, presented on the floor at the annual meeting, subject to favorable letter ballot of Committee C-9:[1]

Section 4.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> The sodium silicate shall be delivered [in 50 to 55-gal. non-returnable steel drums] *on the job in containers of suitable size and of a type which will not cause any deterioration of the product prior to its application to the concrete.* The name of the manufacturer, the actual net weight and *the manufacturer's* grade [of sodium silicate] *designation* shall be plainly marked on each container.

Section 5.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> 5. Sodium silicate may be sampled for purpose of tests either at the plant prior to delivery or on the site of the work, at the option of the purchaser. At least one sample from [every ten drums] *each 500 gal.* shall be taken to determine compliance with these specifications.

The proposed Tentative Method of Test for Coal and Lignite in Sand appearing in the report as preprinted was withdrawn by the committee for further study. The Tentative Specifications for Curing Portland-Cement Concrete (C 80 – 31 T), for Curing Portland Cement Concrete Slabs with Bituminous Coverings (C 81 – 31 T), for Curing Portland-Cement Concrete Slabs with Calcium Chloride Admixture (C 82 – 31 T), for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride (C 83 – 31 T) and for Curing Portland-Cement Concrete Slabs with Wet Coverings (C 84 – 31 T) were approved for reference to letter ballot of the Society for adoption as standard. Attention was called to an abstract appended to the report of an unpublished paper by C. L. Ford on "Comparison of Standards for Colorimetric

---

[1] The proposed revisions were submitted to letter ballot of Committee C-9 which consists of 58 members; 33 members returned their ballots, all of whom voted affirmatively.

Test for Sand." A paper entitled "A Study of the Permeability of a Few Integrally Waterproofed Concretes," by W. M. Dunagan and G. C. Ernst, appended to the report, was presented by H. J. Gilkey and discussed.

A paper entitled "Effect of Duration of Moist Curing on the Principal Properties of Concrete," by A. G. Timms was presented by the author and discussed.

A paper entitled "Plastic Flow of Concrete Under Sustained Stress," by R. E. Davis, H. E. Davis and J. S. Hamilton was presented by H. E. Davis and discussed.

A brief recess in the program was then announced by the chairman during which the prizes for the seventeenth annual golf tournament were presented. The announcement of the winners and the award of the prizes were made by J. H. Chubb on behalf of the Entertainment Committee. The A.S.T.M. Championship Golf Cup for low gross score was won by C. M. Loeb, Jr. Other prize winners in the tournament were: H. Spencer, J. J. Crowe, W. B. Price and C. E. Kinney.

At the suggestion of Mr. Kinney, Mr. Chubb appointed T. A. Hicks and W. B. Price to prepare on behalf of those who had participated in this and previous golf tournaments, an expression of sympathy on the sudden death of E. D. Boyer, for many years the chairman of the Golf Tournament Committee, to be sent to Mrs. Boyer.

A paper entitled "Proposed Method of Making Compression Tests on Portions of Concrete Beams from Flexure Tests," by L. H. Koenitzer was presented by W. E. Gibbons and discussed.

The report of Committee C-13 on Concrete Pipe was presented by the chairman, A. E. Phillips. The proposed revision of the Standard Specifications for Concrete Sewer Pipe (C 14 – 24) in the form of separate tentative specifications entitled "Tentative Specifications for Non-Reinforced Concrete Sewer Pipe," was accepted. The proposed revisions of the Tentative Specifications for Reinforced-Concrete Pipe (C 75 – 30 T) were accepted with the following additional modifications, presented on the floor at the annual meeting, subject to favorable letter ballot of Committee C-13,[1] the specifications as revised to be continued as tentative:

Table I.—Change the minimum design requirements of the standard reinforced-concrete sewer pipe from "4500 lb. per sq. in." to read "3500 lb. per sq. in." and the "5000 lb. per sq. in." to read "4000 lb. per sq. in."

Table II.—Change the minimum design requirements of the extra-strength reinforced-concrete sewer pipe from "3500 lb. per sq. in." to read "4000 lb. per sq. in." and the "4500 lb. per sq. in." to read "5000 lb. per sq. in."

Change the ultimate load under the sand-bearing method for 60-in. diameter pipe from "10,900 lb. per sq. in." to read "10,800 lb. per sq. in."

There being no further business the chairman then declared the Thirty-seventh Annual Meeting adjourned *sine die.*

---

[1] The proposed revisions were submitted to letter ballot of Committee C-13 which consists of 21 members; 13 members returned their ballots, of whom 12 voted affirmatively and 1 negatively.

ANNUAL ADDRESS BY THE PRESIDENT

Thomas R. Lawson

June 27, 1934

During the past few years great changes have occurred in our country. First came the great inflation period after the war, culminating in the peak of 1929. This was followed by the great depression from which we are only now just emerging.

Not only has industry of all kinds been affected by the depression but the various scientific and technical societies have also had to share in the losses that have occurred. Our Society too has had to share in the vicissitudes of the times, and a review of its record during the past and present, together with a discussion of its future, seems to be a timely topic for consideration at this meeting.

When the American Society for Testing Materials was incorporated in 1902, it had 175 members. This represented an increase of a little over 100 from the time when the American Section of the International Association for Testing Materials was formed in 1898. That there was a real need for an organization of this character has been evidenced by the remarkable growth that has occurred since that time. Reference to the accompanying chart will show that the rate of growth has been fairly uniform. In 1930, the maximum membership of 4417 was reached; then, the effect of the depression began to be felt, and for the first time in the history of the Society the losses exceeded the number of new members, the membership dropping to 3532 at the end of 1933.

This was approximately the membership in 1924. In other words, in three years the Society has lost the membership that it took six years to build up. It is clear that we must build again.

The first active committee of the Society, or more exactly of its predecessor, the American Section, I.A.T.M., was created by the Executive Committee in August, 1898, and had for its subject: The Present Knowledge of Impact Tests. The members of this committee were Professors W. K. Hatt and Edgar Marburg. They presented their first report in Bulletin No. 5, issued in October, 1899, and gave a most comprehensive paper on the subject. This was the first paper presented to the Society, and the thoroughness of the investigation of this subject set a standard which has been characteristic of much of the work of this Society.

In January, 1899, the Executive Committee appointed three additional committees as follows:

"On the Application and Specifications of Basic Open-Hearth Steel for Bridges, and Bessemer Steel for Rails."

"On Proper Heat Treatment for all Grades of Iron and Steel, Especially in Rolling and Forging."

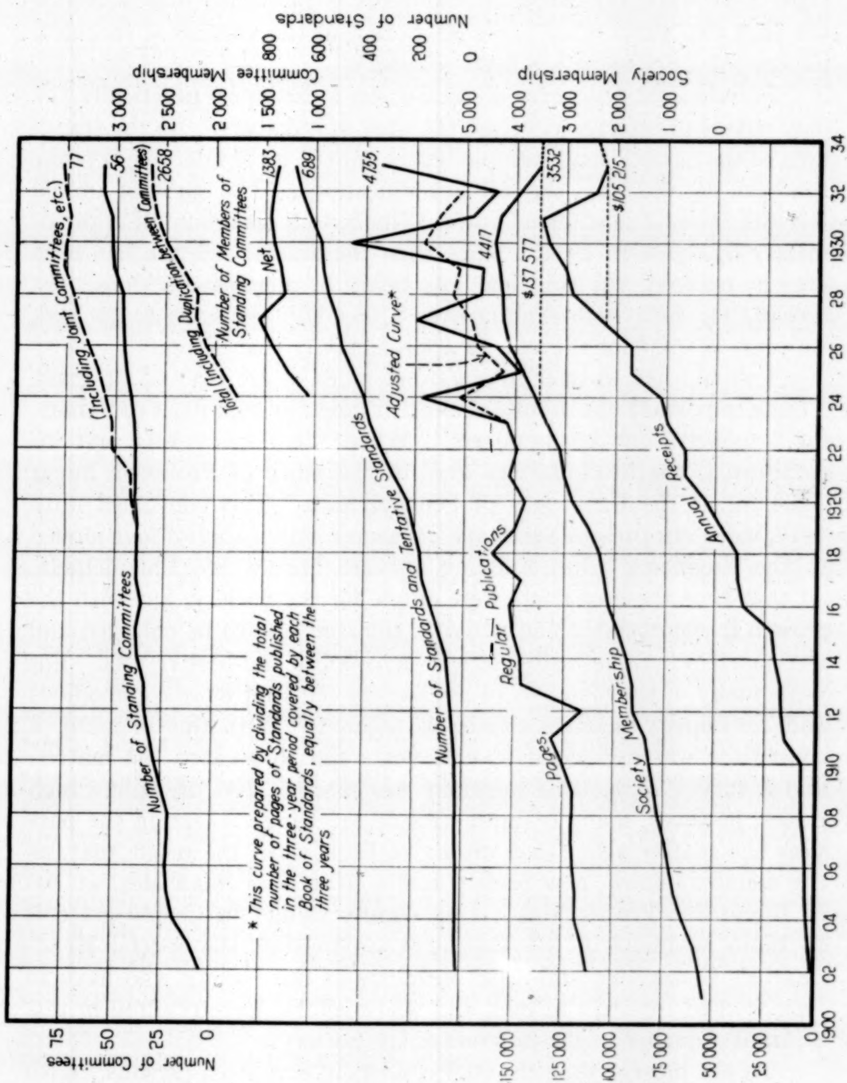
"On the Relation Between the Chemical Composition and the Physical Properties of Iron and Steel, Especially in Connection with Finishing Temperatures."

Chairmen were appointed for each of these committees who had the power to choose the other members of the committee.

With this small beginning, the committee work of the Society has expanded until at present there are 56 standing and research committees. If joint committees and sectional committees are included, the number is increased to 77. The personnel of the standing committees has grown from the original two in 1898 to over 2650 in 1933. Many members serve on more than one committee; the number of members of the Society engaged in its committee work at the present time is nearly 1400.

The first proposed standards were issued in May, 1900, as Bulletins Nos. 8 to 17 of the American Section. These standards all dealt with iron and steel. In fact, the only engineering materials that were under consideration by the American Section at that time were the ferrous metals. From the incorporation of the Society in 1902 until 1910 there were but few additions to the standards. From this time on, however, the committees became much more active, the spirit of cooperation between producer and consumer spread among many industries, and the number of standards increased rapidly. At the end of 1933 the standards and tentative standards numbered 689. This very remarkable growth is a fair index of the activity of the Society as well as the important place it occupies in the standardization and testing of engineering materials.

In the earlier days a single volume sufficed to cover all the annual literature of the Society. At the present time the regular publications, received by all members, include the Year Book, Proceedings (in two parts), Book of Standards (in two parts), Supplements to Book of Standards, Index to Standards and Tentative Standards, Bulletin and Regional Meeting Symposiums. In addition, a number of special publications, including reprints, are issued for sale, the more important being the Book of Tentative Standards and the compilations of standards applying to various fields of materials. It will be seen from the chart that the curve showing volume of regular



* This curve prepared by dividing the total number of pages of Standards published in the three-year period covered by each Book of Standards, equally between the three years.

publications has trended steadily upward, with marked peaks every third year when the Book of Standards is published and a decline the past two years when some restriction in the volume of technical papers and discussions has been necessary.

For the first ten years of the Society's existence, practically the only source of income was from the dues of members. As the standards of the Society have become better known, a considerable revenue has been derived from the sale of publications. The curve of annual receipts shows a continuous upward climb, to a maximum of approximately $137,500 in 1931. Since then the annual revenue has been greatly reduced, the principal loss being in membership dues; the receipts for 1933 were slightly over $105,000. We have to go back six years to 1927 for the year of approximately that income.

I should like to refer to one other index of growth and progress, a quite important one despite the fact it does not lend itself to "charting," namely, our headquarters. When the Society was first incorporated, the headquarters were in the office of Professor Edgar Marburg at the University of Pennsylvania. This continued until 1919, when our present Secretary-Treasurer with a staff of four moved to the Engineers' Club Building at 1315 Spruce St., Philadelphia. At that time these quarters were ample for the Society, but with the growth in membership and activity, the staff had to be enlarged and the quarters became inadequate to accomplish the best results. For years many of the members of the Society felt that more commodious and convenient quarters should be secured. With this in mind, a committee was appointed several years ago to go into the matter, and a survey of possible locations was made. The prevailing high prices, however, made it impracticable to change. During the past year the matter again took on active form, with the result that, as the members know, new Society rooms have been established at 260 S. Broad St., Philadelphia. Our Society should be deeply grateful to those members of the Executive Committee, the special Headquarters Committee and other members of the Society who have so long worked toward this end, and whose efforts have resulted in this desirable advance in the progress of the Society.

At the present time the staff consists of seventeen persons. With return to prosperity, and the prospect of much additional work, it is clearly evident that this number will have to be increased, and in time even larger quarters will have to be secured.

I have traced very briefly the development of some of our activities. What is the significance of this review? Mr. Chapman in his address a year ago likened the Society in certain aspects of its work to a machine, built to turn out a certain line of products, namely, tests and specifications. It is clear that the output of this machine has grown steadily. Publications and standards are measures of the Society's tangible accomplishments and they have been moving continuously ahead throughout the years. Even during the past two or three years, with decreased membership and income, the volume of standardization has increased its rate of growth, and in a sense the Society faces at the moment a task of 1934 proportions with a 1924 membership and a 1927 income. The problem of carrying out its work with reduced income has been no small task, and much credit is due to those who have labored so faithfully and conscientiously to carry on under the trying conditions brought about by the depression. The Society has lived within its income, and in no way has the efficiency of the organization been lessened.

Of course, these adverse membership and financial conditions will not continue indefinitely. Indeed, with the beginning of 1934, a change has been experienced, and it seems safe to say that the sharp downward trend of the membership curve will be halted this year and that the income curve will turn decidedly upward. Quite clearly, the evidences of returning prosperity and the definite upward trend in the business world are being reflected in these two "barometers" of Society affairs, and the prospect for the future is decidedly brighter.

And now, will you look with me for a moment into our future? There is much important work to be done. Our committees will need to keep our specifications and tests abreast of developments, which sometimes take place with startling rapidity in this age of scientific research, and to study new materials as these emerge from the laboratory stage to take their place in the industrial world. There are materials fields into which the Society has not carried its work, some of which have only recently developed from the introduction of entirely new engineering materials, involving new beginnings and many new research problems. The Society must expand its activities to cover the more important of these fields whenever the industries concerned, both producing and consuming, are prepared to enlist its aid in the study of the properties of these new materials and the development of tests and specifications.

All of this means a gradual expansion of our work. Each new group of materials studied carries with it the obligation to publish reports, research papers and standards. Moreover, expansion of the Society *Bulletin* along lines that were determined a year ago is of prime importance in our immediate future, but has had to be deferred for a time because of inability to finance it.

To support this work adequately, the income of the Society must be increased. We must first of all recover our membership. Our efforts in this direction have been intensified beginning this year and they must be productive of results if the Society is to continue to flourish. Even with restored membership, however, the income from individual and company membership dues and publication sales will not be sufficient to carry out the expanding program of the Society. Increased financial support from Industry is needed and this is afforded through the class of Sustaining Membership established three years ago. Industrial conditions prevailing since that time have not been favorable to securing many such memberships, but with improvement in business and appreciation by our industries of the value of the Society's work to them, many Sustaining Members can, I am satisfied, be secured.

Efforts have been made to increase the membership of the Society among the students of the various technical schools and colleges. The book of "Selected A.S.T.M. Standards for Engineering Students," containing many of the specifications and tests used in college laboratories, has been favorably received and is widely used. While this book operates somewhat to the disadvantage of student membership, for many students are content to go no farther for the time being than simply to purchase the book, it does introduce them to the work of the Society and undoubtedly will be instrumental in a larger use of the Society's standards in their post-college work. Some of our members have financed a number of student memberships at the schools or colleges from which they have graduated or in which they have some special interest. Usually awards of these memberships are made to students who have shown superior proficiency in some line of testing work. There is an opportunity here for many of our members to render a service to the Society by increasing the number of these complimentary memberships.

The subject of a Research Fund has long been active in the minds of members of the Society. As long ago as the Second Annual Meeting held in 1899, Professor James M. Porter introduced this subject, advocating the establishment of a "publication and research fund," and made a subscription of $100. This was followed by a subscription for an equal amount by Mr. Robert A. Carter. With this nucleus, a fund was created that for several years supplemented the small income from dues. As the various research projects were developed under the auspices of our committees, they drew a large measure of support from the members and from the industries, often in the form of direct financial contributions to the specific project.

The organization of Committee E-9 on Research in 1924 centered attention upon the fundamental importance of research to the advancement of the purposes of the Society and the need of funds under the control of the Society for support of researches in materials. In 1927 the Executive Committee established our present A.S.T.M. Research Fund with the investment of $1000, and the Fund has since grown to slightly over $8000 by addition of half the entrance fees until 1930. It is still much too small to be very effective, and in recognition of that fact the Executive Committee has appointed a committee of three members noted for their deep interest in this subject—Past-Presidents F. O. Clements, K. G. Mackenzie and H. F. Moore—which is now actively engaged in perfecting plans for adding materially to the Research Fund.

I am confident that every member who will think seriously of this subject will realize its importance and will aid the upbuilding of this Fund in every way he can.

I should like for a moment to refer to a subject that has been before us this year, of which mention is made in the annual report of the Executive Committee. The relationship of the Society to the National Recovery Administration has gradually been unfolding during the year in which the Administration has functioned. While the development and operation of the N.R.A. Codes are in quite a state of flux at the moment, we have noted at least sixty such codes, with their Code Authorities, under which industries represented in the Society membership or dealing with materials that fall within the Society's scope, are operating today. It is difficult to forecast the extent to which it may be necessary for these industries, in operating under such codes, to set up minimum standards of quality for the materials they produce and to establish a procedure for assuring conformity to such standards in the interest of "fair competition." But clearly, whatever the ultimate developments may be, the specifications and tests standardized by this Society and the facilities it has established for the orderly formulation of standards of quality lie ready at hand for these industries and the Administration to utilize and we have tendered these facilities to the Administration and the Code Authorities as an aid in the development of such standards with a minimum of "lost motion" and duplication of work.

This is but one way in which the Society may aid substantially in the program of national recovery, and I would suggest to our members in these "code" industries that they can render a worth-while service to their industries and to the Society by using their influence in having our standards recognized under code procedures and our

Society invited to assist in the development of standards for materials and products within our scope.

On the administrative side, we need to consolidate our standardization activities, to review our procedures and methods, and especially to develop our relations with other societies both individually and through such agencies as the American Standards Association, to the end that associations in other fields of engineering, chemistry and technology as well as the industries of the country will to an ever increasing extent look to our Society as the ultimate authority in matters concerning properties and standards for the materials of engineering, and will cooperate with us in the conduct of research and the promulgation of standards in this special field upon which we have been concentrating our efforts for upwards of thirty-five years.

The Society is concluding with this annual meeting a year of activity and accomplishment. Splendid opportunities lie ahead of us. Let us lay an adequate foundation in our committee work, in our methods of operation and especially in our provision for research in the properties of materials, that this Society may continue to render the same great service to the engineering world that it has in the past.

ANNUAL REPORT OF THE EXECUTIVE COMMITTEE

The Executive Committee offers the following report on general Society activities for the year ending with this annual meeting:

Membership:

The membership of the Society on June 1, 1934, was 3569. Statistics showing gains and losses in the various classes of membership are as follows:

Class of Members	Membership		Losses				Additions		Total		
	June 1, 1933	June 1, 1934	Resignations	Dropped	Death	Transfer	Transfer	Election	Loss	Gain	Decrease
Honorary	3	2	...	....	1	...	...	...	1	...	1
Life or Perpetuity	11	11	...	....	...	...	...	...	...	...	....
Sustaining	6	6	...	....	...	...	...	...	...	...	....
Company, Firm, etc.	901	856	32	35	...	10	2	30	77	32	45
Individual, etc	2762	2649	128	193	20	2	18	212	343	230	113
Junior	50	45	3	6	...	8	...	12	17	12	5
Total	3733	3569	163	234	21	20	20	254	438	274	164
Student	126	139	12	64	...	4	...	93	80	93	13[a]

[a] Increase.

The above table presents a much more encouraging picture than prevailed a year ago and reflects the material improvement that has been made since the turn of the year. While there has been a net loss in Society membership of 164, the net loss reported a year ago was 430. Resignations for the year are much fewer, 163 compared to 382; losses from all sources this year are 438, compared to 652 a year ago. At the same time there has been an increase in the number of new members elected, 254 being reported now compared to 170 reported a year ago. The number of student members has increased from 126 to 139.

The greatly decreased number of resignations is to be attributed in part to the improved tone of business generally and a lessening of the uncertainty that prevailed a year ago. This improvement in conditions also accounts in part for the increase in number of new members, although here the efforts of the Special Committee on Membership, consisting of Messrs. K. B. Cook, chairman, Arthur W. Carpenter, H. G. Farmer, H. M. Hancock, Inge Lyse and H. S. Vassar, are clearly beginning to show results. So many members who have resigned within the past two or three years have done so only because of financial stringency, that the Executive Committee is confident many of them will resume their membership as soon as it is possible for them to do so. Contact has been established with many of these former members through communications addressed to them within the past few months. The special roll mentioned in last year's report has been maintained, on which is placed the name of any member obliged to resign who would like to continue to receive the A.S.T.M. *Bulletin*, program of the annual meeting and in other ways keep in touch with Society activities. At present there are about 45 individuals and companies on this roll. The Executive Committee has continued to recognize and meet in so far as it could the pressure on financial resources of many members in these times. The plan of payment of annual dues in two installments where desired has been continued and the date by which members delinquent for the previous year's dues could make payment has again been extended.

The Society has lost the following members through death:

	Date of Membership		Date of Membership
Chase, Clement E.	1914	Hartzell, Harry S.	1913
Churchill, Charles S.	1900	Hofmann, H. E.	1927
Churchward, Alexander	1909	Lynch, T. D.	1902
Claiborne, Charles H.	1914	Mayer, T. Otto	1921
Cleland, William	1928	Millwood, James P.	1910
Cushman, Henry Percy	1924	Newhall, Henry B.	1926
Everest, A. R.	1915	Rightmire, R. E.	1927
Flagg, Stanley G., Jr	1899	Stal, Wladimir D	1931
Franklin, Arthur C.	1932	Stevenson, A. A.	1896
Gibboney, J. H.	1906	Watson, Robert M.	1927
Green, J. B.	1926	Wood, Walter	1900

Among these are three men to whom the Society will forever be indebted for outstanding service and accomplishment: J. H. Gibboney, President 1926–1927, T. D. Lynch, President 1929–1930, and A. A. Stevenson, President 1916–1917 and Honorary Member since 1927. The deaths of these three men, all within a space of less than two months, saddened the hearts of members throughout the entire Society. Each had a host of friends among the membership; each was loved for the fine personal and human qualities he possessed, and honored and respected for outstanding accomplishments in both technical and business circles and in the advancement of Society affairs. Suitable resolutions were adopted by the Executive Committee and published in the Society *Bulletin;* engrossed copies were presented to the families of these friends who have passed on.

Other members distinguished in service in the Society are among those who have passed away. Charles S. Churchill was active in the earlier days of the Society and had served as a member of the Executive Committee 1912–1914. Stanley G. Flagg, Jr., had long taken an interest in the Society's work in the fields of iron and steel. Walter Wood had also since the very beginning of the Society been interested in these same fields and was the first chairman of the Committee on Cast Iron. He took an active part in the work of the first International Association for Testing Materials. Other members who had been active in various phases of the Society's work were Clement E. Chase, Charles H. Claiborne, J. B. Green, Harry S. Hartzell, H. E. Hofmann, James P. Millwood and R. E. Rightmire.

Student Membership.—The Executive Committee wishes again to emphasize the importance of the class of student members. Not alone is such membership of obvious value to the student himself, but the association thus formed is of much value to the Society since the technical student of today is the A.S.T.M. member of tomorrow. Attention is again called to the plan of awards of student membership that have been established as prizes by a few members of the Society as a means of introducing the idea of student membership in certain schools and bringing an increasing number of young students into touch with A.S.T.M. work. The following prize awards have already been established for the number of years stated: Cornell University, by J. B. Johnson—two years, three memberships each year; Lehigh University, by Henry A. Gardner—one year, ten memberships; Massachusetts Institute of Technology, by Arthur W. Carpenter—two years, five memberships each year; Rensselaer Polytechnic Institute, two years, five memberships each year—the first year by George C. D. Lenth, the second by President T. R. Lawson; and the University of Pennsylvania, by the Secretary-Treasurer, C. L. Warwick—two years, three memberships each year. A description of this plan was sent to a selected group of Society members a few weeks ago and two further awards have been established: one of five student memberships at Detroit Institute of Technology by Past-President F. O. Clements; the other, five student memberships at Grove City College by Arthur E. Pew, Jr. The Executive Committee hopes this plan will be still further supported by the members.

A student society for testing materials has been formed at New York University under the sponsorship of Prof. C. T. Schwarze around a nucleus of several student members. It is planned to hold periodic meetings addressed by members of the Society. President Lawson at Rensselaer Polytechnic Institute and Prof. James R. Withrow at Ohio State University have for some years been actively interested in promoting student membership at their respective institutions.

Recovery of Membership.—Mention was made previously of the efforts of the Special Committee on Membership. The plans of this committee and the progress it makes in its work are discussed currently in the A.S.T.M. *Bulletin*. It is not intended here either to present these plans or to discuss them. The Executive Committee simply wishes to point out, as it has in the past, that the source of the strength and virility of the Society lies in its membership. Not only must we get back on our rolls as many as possible of those who have temporarily been obliged to sever their connection with our work, but we must also bring new men and new companies into it. To an increasing degree the study of properties of materials and the development of tests and specifications is extending into new industrial fields. The Society is in a position to serve these various industries and groups just as effectively as it has served for many years those groups now active in its affairs; but the first step is to bring the work the Society is doing to the attention of those that compose these new groups and to point to the opportunities that membership in A.S.T.M. will afford these groups to study the materials and testing problems that are continually arising in their work. These are the ultimate aims of the membership work that is now under the general direction of the Special Committee. Provision has been made in the Society's staff for continuous effort along these lines in conjunction with the Special Committee, and there is much encouraging evidence that many members of the Society are fully alive to the importance of this work and are prepared to help it in every way they can. There is no better way of building up the strength of the Society through membership than by personal efforts of our own members and the Executive Committee speaks most earnestly for a sincere and hearty response of the members in all that they may be asked to do during the coming year.

Committee Activities:

Again we come to an annual meeting of the Society with a splendid record of committee accomplishments for the year. Only very few of the Society's committees seem to have found it difficult or impossible to make progress in their assigned fields during the past year; nearly all of our committees, including sectional committees under Society sponsorship, are reporting substantial progress in development of standards or in investigative work or both. The program of the present annual meeting is its own evidence of the fruitful committee work of the year. As usual, the reports of two administrative committees, E-9 on Research and E-10 on Standards, supplemented by reviews in the July and October issues of the *Bulletin*, give a general summary of these activities, so the present report will deal only with administrative matters.

The administrative work of Committee E-10 on Standards continues to grow in importance. The submission of proposed new tentative standards for consideration of Committee E-10 between annual meetings has worked well; in particular, submission during the summer has given standing committees an opportunity to have included in the current issue of the *Proceedings* and the Book of Tentative Standards new specifications and methods that were not fully ready for presentation at the annual meeting. Review of such proposed new tentative standards by Committee E-10 is quite critical and the standing committees must show a very substantial consensus of opinion within the committee in support of the new specification or method before it will be accepted for publication as tentative.

In view of a specific case that arose following the annual meeting of the Society last year, the Executive Committee extended the authority of Committee E-10 to include the withdrawal of a standard on the request of a standing committee in cases where a tentative standard is to supersede immediately the standard withdrawn.

A study of certain features of the Society's standardization procedure made by a committee of the Executive Committee and by Committee E-10 on Standards has led to an extension of that procedure permitting the publication as information of proposed specifications or methods in the Society *Bulletin* and possibly in trade journals, such publication to require the endorsement of the standing committee by such procedure as the committee itself may prescribe and the approval of the Secretary-Treasurer. Such specifications or methods published for information will carry a suitable note calling attention to the fact that the specification or method is published simply as information and does not have any official status in the Society as either a tentative standard or a standard. Publication of such documents in the Society *Bulletin* is one of the directions in which expansion of the *Bulletin* is planned.

A further outcome of the studies just mentioned has been a codification of the Society's regulations governing standardization procedure primarily for the guidance and use of committee officers in handling their various standardization activities.

Considerable attention has been given both by the Executive Committee and Committee E-10 to expansion of the Society's standardization activities in several important directions. A number of suggestions from various sources have been referred to existing committees for development, among them zeolites for water softening to Committee D-19 on Water, asphalt plank to Committee D-4 on Road and Paving Materials, sheet copper to Committee B-5 on Copper and Copper Alloys, Cast and Wrought, and lead-coated copper to Committee B-2 on Non-Ferrous Metals and Alloys. The subject of Methods of Testing Gaseous Fuels was proposed as a promising field in which standardization was needed. A conference on this subject was held last March in Washington, and a study committee appointed at that time will report to the conference at a second meeting during the annual meeting of the Society. The general subject of Soils has been under consideration for some time and an approach is now being made to the subject through Committee D-4 on Road and Paving Materials from the aspect of soil as a subgrade and paving material. A discussion of this subject will be introduced by a paper on the program of this annual meeting.[1] Other subjects being considered are thermal insulating materials, paper and allied products, phenolic and similar resins, and soap having particularly in mind its uses as a lubricant.

The question of jurisdiction as between Committees C-4 on Clay Pipe and C-13 on Concrete Pipe over Definitions of Terms Relating to Sewer Pipe (C 8 – 24) and Recommended Practice for Laying Sewer Pipe (C 12 – 19), referred to in the report a year ago, was determined by assigning sponsorship for these two standards to Committee C-4 on Clay Pipe, with the understanding that they must be suitably edited to apply to clay pipe alone. Committee C-13 had advised the Executive Committee that it was not interested in these standards so far as they applied to concrete pipe and that the provisions applying to concrete pipe should be dropped.

The Executive Committee decided upon representations from Committee D-18 on Natural Building Stones that, inasmuch as that committee is the only one dealing entirely with masonry materials that is not now in the C group in the committee classification, the designation of the committee should be changed from D-18 to C-18, retaining the numerals "18" at the particular request of the committee. At the same time the title of the C group was changed from "Cement, Lime, Gypsum and Clay Products" to read "Cementitious, Ceramic, Concrete and Masonry Materials."

J. R. Dwyer was appointed a member of the Society's staff for one year ending October 31, 1934, and assigned to Committee C-1 on Cement as its technical assistant under the arrangements announced in previous reports whereby funds for his salary, traveling and other expenses as technical assistant are made available by Committee C-1.

---

[1] C. A. Hogentogler and E. A. Willis, "Subgrade Soil Testing Methods," *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part II, p. 693 (1934).

Committee A-1 on Steel has continued the arrangement announced a year ago for the part time services of a member of the Society's staff as staff assistant to the committee officers, supplemented by technical and stenographic services as needed. The expenses are being met from funds contributed by the committee.

District Committees:

The Executive Committee has under consideration plans for the reorganization in some respects of the district committees of the Society, of which there are now eight as follows: Chicago, Cleveland, Detroit, New York, Northern California, Pittsburgh, Seattle and Southern California. A more carefully considered statement of the purposes and functions of the district committees is being drafted; it is proposed that membership on the district committees, which is by appointment by the Executive Committee, be placed on a rotational basis, members serving for a term of three years; and that officers of the district committees be elected by the respective district committees rather than appointed by the Executive Committee. The Executive Committee will give further consideration to these plans at its next meeting, after which they will be discussed with the various district committees.

Meetings:

Since the Thirty-sixth Annual Meeting of the Society last June in Chicago there has been held the Fifth Regional Meeting in Washington, D. C., March 7, 1934. The technical feature was a symposium on The Outdoor Weathering of Metals and Metallic Coatings, sponsored by a committee of members chosen from the personnel of Committees A-5 on Corrosion of Iron and Steel and B-3 on Corrosion of Non-Ferrous Metals and Alloys. The papers and discussions at this symposium dealt primarily with an analysis of performance data obtained from the outdoor weathering tests carried on by these two committees of the Society and brought about one of the most interesting sessions on this subject the Society has ever held. An informal dinner was one of the features of the meeting, which was under the direction of a committee of Washington members headed by Mr. A. C. Fieldner.

The spring group meetings of committees were held at Washington over the dates March 5 to 9, inclusive. The total registered attendance of 584 exceeded the records of any previous group meetings. Throughout this week over 150 committee, subcommittee and section meetings were held; the whole occasion reflected the earnestness of our committees and their members in considering the problems before them and advancing the standardization and research work of the Society.

No meetings under the auspices of the several district committees were held during the year, and in view of the times and the inability to lend adequate financial support to such activities, the Executive Committee has not been inclined to urge too strongly the holding of such meetings. It is believed, however, that under more favorable conditions each district committee should sponsor at least one local meeting annually since such meetings in recent years have contributed much of interest in Society affairs.

Publications:

Since the last annual meeting the following publications distributed to the members were issued: *Proceedings*, including preprints of reports and papers; the 1933 Book of A.S.T.M. Standards, Part I Metals, Part II Non-Metallic Materials; the Index to A.S.T.M. Standards and Tentative Standards; and the Year Book. Six issues of the A.S.T.M. *Bulletin* were published. The Book of A.S.T.M. Tentative Standards and the Symposium on Motor Lubricants, containing the papers and discussions presented at the New York Regional Meeting, March, 1933, were published and furnished to members on order. A comparative statement of the volume of these publications for the past four years follows:

	1930, PAGES	1931, PAGES	1932, PAGES	1933, PAGES
Proceedings	2421	2416	1895	1914
Book of A.S.T.M. Standards	2214	....	....	2348
Supplement to Book of A.S.T.M. Standards	....	144	102	....
Year Book	332	342	....	248
Supplement to Year Book	....	....	133	....
Index to A.S.T.M. Standards and Tentative Standards	113	103	119	124
Book of A.S.T.M. Tentative Standards	864	1008	1236	1164
Regional Meeting Symposium	186	152	159	121
Joint A.S.M.E.-A.S.T.M. Symposium on Effect of Temperature on the Properties of Metals	....	829	....	....
	6130	4724	3644	5919

One publication planned for 1933 had to be deferred until the present year, namely, the report on Significance of Tests of Concrete sponsored by Committee C-9 on Concrete and Concrete Aggregates and presented to the Society at the annual meeting in 1933. The report will appear as a separate book, of which each member has been given an opportunity to request a copy without charge.

Reference is made to the annual report of Committee E-6 on Papers and Publications for further details, including a number of reprints from the 1933 publications, the preprinting of Regional Meeting papers for the Symposium on The Outdoor Weathering of Metals and Metallic Coatings and the preprinting of reports and papers for the present annual meeting. A compilation of standards, entitled A.S.T.M. Standards on Preservative Coatings for Structural Materials (Paints, Varnishes, Lacquers and Paint Materials), prepared under the auspices of Committee D-1 on Preservative Coatings for Structural Materials, was published for the first time in the fall of 1933, taking its place with similar compilations of standards in the petroleum, electrical insulating, textile and refractory materials fields.

The finances of the Society have not as yet permitted the expansion of the A.S.T.M. *Bulletin* along lines defined a year ago.[1] While this expansion is felt to be highly desirable, it is considered to be still more important not to curtail in any way the publication of standards and tentative standards of the Society and to curtail as little as possible the publication of committee reports and technical papers. After these requirements were provided for in the current budget, funds were not available to permit expansion of the *Bulletin* on the scale desired. It is, however, intended to make a start in the direction of an enlarged *Bulletin* just as soon as the way ahead seems reasonably sure.

Finances:

Report for the Fiscal Year 1933.—The annual statement of the finances of the Society follows in the report of the auditors for the fiscal year January 1 to December 31, 1933.

REPORT OF THE AUDITORS FOR THE FISCAL YEAR, JANUARY 1, 1933, TO DECEMBER 31, 1933

PHILADELPHIA, January 13, 1934.

Mr. C. L. Warwick, *Secretary-Treasurer*,
AMERICAN SOCIETY FOR TESTING MATERIALS,
Philadelphia, Pa.

Dear Sir:

We have examined the books and accounts of your Society for the year ended December 31, 1933.

As a result of our examination we have prepared the annexed Balance Sheet as of December 31, 1933, and the Statement of Cash Receipts and Disbursements for the twelve months then ended, together with other supporting schedules. The Balance Sheet, in our opinion, correctly reflects the financial position of the Society at the close of the year 1933 and is in agreement with your records.

We have verified 1933 transactions as summarized in your budget record and found your records in this respect correct.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 39–40 and 493–494 (1933).

Investments owned were verified by actual inspection and count and found to be intact and in agreement with the schedule of securities owned as detailed herewith. We verified the collection of interest on investments owned for the year 1933 and find it fully accounted for, except that the interest due September 1, 1933, on $6000 Missouri Pacific Railroad First and Refunding Mortgage 5's was not collected. We understand this interest is in default and the coupons were attached to the bonds examined.

We found the books and accounts examined in their usual satisfactory condition.

We take this occasion to express our appreciation for the courteous cooperation extended our representatives during the course of our mid-year and end-of-year examinations.

Respectfully submitted,
(Signed) JOHN HEINS AND CO.

BALANCE SHEET AS OF DECEMBER 31, 1933

ASSETS

Current Funds		$7 869.45	
Investments		38 266.50	
Accounts Receivable:			
For Publications	$8 039.26		
Advertising	1 399.80		
Members, for 1933 Dues	4 277.17		
Members, for Entrance Fees	165.50		
Members, for Binding	36.50		
Members, for Inter. Assn. Dues	28.00		
		13 946.23	
A.S.T.M.–A.S.M.E. Symposium on Effect of Temperature:			
Special Account for Financing Book		2 735.39	
Furniture and Fixtures		6 092.51	
Girard Trust Company Closed Banks Account		58.16	
			$68 968.24

LIABILITIES

Publications paid for in advance		$316.65		
Advertising paid for in advance		40.20		
Members Dues paid in advance		958.97		
Members Binding paid in advance		3.00		
Members Dues in Inter. Assn. paid in advance		4.00		
Entrance Fees paid in advance		120.00		
			$1 442.82	
Committee A-1 for Technical Assistant			65.00	
Committee C-1 for Technical Assistant			335.74	
International Assn. for Testing Materials			34.35	
Income, A.S.T.M. Research Fund			1 301.07	
Life Membership Fund	$3 005.20			
A.S.T.M. Research Fund	8 179.35			
Headquarters Fund	4 809.13			
Publications Fund	3 015.00			
		$19 008.68		
Surplus		46 780.58		
			65 789.26	
				$68 968.24

RECEIPTS AND DISBURSEMENTS

JANUARY 1, 1933, TO DECEMBER 31, 1933

Current Funds, January 1, 1933 (including investments at book value)			$5 945.05
RECEIPTS			
Current Dues	$61 854.44		
Past Dues	1 184.88		
Advance Dues	943.97		
Income, Life Membership Fund	150.00		
Entrance Fees	1 419.50		
Total Dues		$65 552.79	
Separate Standards	$3 284.70		
Book of Standards	4 475.29		
Book of Standards—Members for both parts	3 844.00		
Book of Tentative Standards	2 519.93		
Proceedings	3 287.56		
Selected Standards for Students	705.55		
Miscellaneous (including special reprints)	10 334.98		
Total Sales of Publications		28 452.01	
Binding (Members)		607.50	
Advertising in Bulletin		2 791.11	
Advertising in Index to Standards and Tentative Standards		441.00	
Authors' Reprints		138.00	
Sale of Certificates of Membership		7.50	
Interest on Deposits and Investments		3 368.00	
Investments matured or sold		24 520.00	
Accrued interest		102.72	
Excess Remittances		73.29	
Symposium on Effect of Temperature		262.90	
Income, A.S.T.M. Research Fund		383.75	
Registration and other fees, Annual Meeting		705.00	
International Association for Testing Materials, Dues		554.00	
International Assn. for Testing Materials, Publications and Deficit		284.96	
Committee C-1 for Technical Assistant		1 916.67	
Committee A-1 for Technical Assistant		1 125.00	
Contribution from Medal and Lecture Fund toward cost of publishing Marburg Lecture		500.00	
Exhibit, Annual Meeting		1 120.00	
Miscellaneous		56.51	
Total Receipts			132 962.71
Carried forward			$138 907.76

Brought forward			$138 907.76
DISBURSEMENTS			
Publications:			
Year Book	$1 914.73		
Book of Standards	18 560.13		
Book of Tentative Standards	2 711.50		
Proceedings	16 983.18		
Preprints	2 035.34		
Bulletin and Circular to Members	3 812.60		
Separate Standards	1 977.12		
Index to Standards and Tentative Standards	1 303.18		
Regional Meeting Papers	481.57		
Miscellaneous (including special reprints)	4 598.67		
		$54 378.02	
Salaries		40 755.41	
General Office Expenses		7 863.70	
Expenses, Standing Committees		2 245.36	
Expenses, Meetings		2 494.12	
Traveling Expenses—Administrative Committees		1 444.63	
Rent and Insurance, Storage Rooms		433.50	
Rent, Headquarters		2 400.00	
Headquarters Maintenance		194.57	
Furniture and Fixtures		467.79	
Certificates of Membership		21.50	
American Standards Assn. and Sectional Committees		1 425.00	
Investments		15 125.00	
Accrued interest		74.38	
Refund of Excess Remittances		73.29	
Symposium on Effect of Temperature		14.76	
International Assn. for Testing Materials, Dues		603.95	
International Assn. for Testing Materials, Publications and Deficit		284.96	
New Headquarters		220.87	
Technical Assistant, Committee C-1		1 765.20	
Miscellaneous		112.85	
Total Disbursements			132 398.86
			$6 508.90
To increase balance of current funds by difference between book values of investments comprising part of current funds at December 31, 1933, $15,860.55 (with a then market value of $17,595.00), and the book values of investments comprising part of current funds at January 1, 1933, $14,500.00			1 360.55
Balance, Current Funds, December 31, 1933			$7 869.45

Balance accounted for as follows:

Cash on hand		$2 208.90	
Investments at book value carried as cash:			
$7 000 U. S. Liberty Bonds 4th, 4¼'s	$7 061.25		
3 000 Am. Tel. & Tel. Bonds, Series F, 5's, 1960	3 159.75		
500 Consolidated Gas Co. of N. Y. Bonds, 5½'s, 1945	531.00		
10 000 New York Central Bonds, 5's, 2013	5 108.55		
(Market Value, December 31, 1933, $17,595)		15 860.55	
		$18 069.45	
Less checks drawn but not paid against cost of Proceedings		10 200.00	
			$7 869.45

A. S. T. M. RESEARCH FUND
(included in Society Funds)

Balance, January 1, 1933:		
Principal	$8 179.35	
Income	917.32	
		9 096.67
Receipts		
Interest on deposits and investments		383.75
		$9 480.42
Disbursements		
None		
Balance, December 31, 1933:		
Principal:		
Investments	$8 141.75	
Cash	37.60	
	$8 179.35	
Income	1 301.07	
		$9 480.42

FINANCIAL CONDITION AT CLOSE OF FISCAL YEARS 1929–1933, INCLUSIVE.

Fiscal Year	Assets				Liabilities			
	Current Funds	Investments	Accounts Receivable and Miscellaneous	Furniture and Fixtures	Accounts Payable and Miscellaneous	Reserve for Book of Standards	Special Funds	Surplus
1929	$3 683.76	$54 707.09	$6 226.93	$5 896.31	$1 913.27	$12 012.80	$19 438.05	$37 149.97
1930	4 567.78	44 255.51	10 873.38	6 209.36	2 935.58	....	20 438.05	42 532.40
1931	6 414.07	49 946.21	12 668.06	6 571.94	3 905.00	5 690.70	19 438.05	46 566.53
1932	5 945.05	49 035.80	14 834.01	6 301.67	2 077.61	11 743.20	19 229.55	43 066.17
1933	7 869.45	38 266.50	16 739.78	6 092.51	3 178.98	....	19 008.68	46 780.58

In addition to the regular Society funds the Secretary-Treasurer has on hand the following funds:

COMMITTEE FUNDS

Committee A-1 on Steel	$507.03	
Committee A-3 on Cast Iron	30.19	
Committee A-5 on Corrosion of Iron and Steel	6 664.25	
Committee A-5, Subcommittee X on Embrittlement Investigation	128.89	
Committee B-3 on Corrosion of Non-Ferrous Metals	3 508.55	
Committee B-6 on Die-Cast Metals and Alloys	263.02	
Committee C-1 on Cement	919.86	
Committee C-1, Cement Reference Laboratory	1 090.30	
Committee C-9 on Concrete and Concrete Aggregates	619.47	
Committee C-10 on Hollow Masonry Building Units	250.78	
Committee D-1 on Preservative Coatings	32.84	
Committee D-14 on Screen Wire Cloth	54.62	
Committee D-18 on Natural Building Stones	.03	
Joint Committee on Investigation of Phosphorus and Sulfur in Steel	368.06	
A.S.A. Sectional Committee on Specifications for Cast-Iron Pipe	2 197.66	
A.S.A. Sectional Committee on Classification of Coals	1 120.63	
Total Committee Funds		$17 756.18
Accounted for as follows:		
Investments	$6 119.92	
Cash on hand	11 636.26	
		$17 756.18

DUDLEY MEDAL AND MARBURG LECTURE FUND

Balance, January 1, 1933:		
Investments	$6 625.00	
Cash on hand	1 047.46	
		$7 672.46
Receipts		
Interest on Deposits and Investments		338.45
		$8 010.91
Disbursements		
Cost of 1933 Medal	$80.00	
Honorarium, 1933 Lecturer	200.00	
Engrossing 1933 Lecture Certificate	3.25	
Contribution toward cost of publishing Lecture	500.00	
Miscellaneous	46.64	
		829.89
		$7 181.02
Balance, December 31, 1933:		
Investments	$6 625.00	
Cash on hand	556.02	
		$7 181.02

INVESTMENTS, DECEMBER 31, 1933

SOCIETY FUNDS

			Book Value	*Market Value*
General:				
$2 000	Penna. R. R. Bonds, Seconds, 5's, due 1964		$2 000.00	$1 830.00
6 000	Southeastern Power & Light Co., 6's Gold Deb., Series A, due 2025		6 240.00	2 640.00
7 000	Baltimore & Ohio R. R. Refunding and General Mortgage Bonds, 5's, due 1995		7 087.50	4 900.00
9 000	Baltimore & Ohio R. R. General and Refunding, 5's, Series F, due 1996		9 106.55	6 300.00
6 000	Missouri Pacific R. R. First and Refunding Mortgage, 5's, Gold Bonds, Series F, due Mar. 1, 1977 (Defaulted September 1, 1933.)		5 690.70	1 545.00
$30 000			$30 124.75	$17 215.00
A.S.T.M. Research Fund:				
$3 000	Baltimore & Ohio R. R. Refunding and General Bonds, 5's, due 1995		$3 037.50	$2 100.00
1 500	Baltimore & Ohio R. R. General and Refunding 5's, Series F, due 1996		1 511.25	1 050.00
1 500	Consolidated Gas Co. of New York Bonds, 20-year 5½'s, due 1945		1 593.00	1 548.75
2 000	First Mortgage Real Estate, 6's Bonds on 1315–17 Spruce St., due 1945		2 000.00	1 200.00*
$8 000			$8 141.75	$5 898.75
$38 000			$38 266.50	$23 113.75
Committee Funds:				
$6 000	U. S. Liberty Bonds, 4th, 4¼'s due 1938:			
	Committee A-5	$5 610.39		
	Committee C-1	509.53	$6 119.92	$6 112.50
Dudley Medal and Marburg Lecture Fund:				
$500	Baltimore & Ohio R. R. Refunding and General Bonds, 6's due 1995		$550.00	$397.50
6 000	Baltimore & Ohio R. R. Refunding and General Bonds, 5's due 1995		6 075.00	4 200.00
$6 500			$6 625.00	$4 597.50
$50 500			$51 011.42	$33 823.75

Market values, unless otherwise indicated, have been taken from the *Philadelphia Inquirer*, January 2, 1934, showing last sale for year 1933.

* No quotation.

For the third successive year in which the Society has faced reduced income, primarily from loss of membership, it has been possible to keep the expenses of the Society within its income without drawing upon its reserves and at the same time to carry on the Society's work without material curtailment. Receipts from dues were about $7000 less than for the preceding year, which in turn had fallen off about $10,000 from the corresponding figure for 1931. Advertising income from the *Bulletin* also fell off during the year. However, these losses were partially offset by increased income from sales of publications and from other sources, with the result that income for the year was only about $4300 under the amount budgeted. Various economies instituted during the preceding year[1] were continued during 1933 and it was found possible to keep the total of current disbursements (with all bills paid) approximately $2700 within current receipts. No investment was made from current receipts towards the principal of the A.S.T.M. Research Fund, for as explained in the report a year ago it has been felt that under present conditions it is more important to conserve funds for publications than to increase the Research Fund.

As a matter of executive policy the surplus from yearly operations from 1930 down to the present have not been added to "permanent" reserve but have been set aside for emergency use. So far it has not been necessary to touch this surplus, which has now reached the approximate total of $10,500. Of this amount the sum of $4800 has been earmarked for addition to the principal of the A.S.T.M. Research Fund, since it represents half of the entrance fees collected during the past four years; the remainder, $5700, is still available as a contingency reserve.

It is desired to emphasize the importance from the financial viewpoint of the continuing and indeed increasing demand for Society publications; income from sales of publications has withstood the pressure of the adverse times and a comparison of the current report with those of previous years will indicate how important a part this source of income has played in enabling the Society to carry on its work through a most difficult period, practically without reducing the services to the Society membership.

The report of the auditors gives the balance sheet of assets and liabilities, statement of receipts and disbursements and comparison of the financial condition of the Society at the close of the past five years. It also gives statements of the A.S.T.M. Research Fund, the Dudley Medal and Marburg Lecture Fund, and funds held for the accounts of committees. Investments of Society and other funds are listed, both book and market values being given. Special funds totaling $19,008.68 are held as detailed in the balance sheet. The reserve for the Book of Standards reported a year ago was applied during the year to the expense of the 1933 Book of Standards.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 48 (1933).

Attention is directed to the Headquarters Fund, which a year ago amounted to $5030 and now appears in the balance sheet as $4809.13. The decrease of $220.87 represents expenditures against removal of headquarters paid during the fiscal year 1933. The remainder of the expense of establishing new quarters, to which reference is made in a later section of the report, was paid in 1934 and therefore is not reflected in the present report of the auditors. Similarly, the value of furniture and fixtures reported in the statement of assets, namely, $6092.51, does not include any of the furniture and fixtures purchased for the new headquarters since these purchases were all paid for in 1934. The effect of the establishment of the new headquarters on these two accounts will be shown in the auditors' report for the fiscal year 1934.

No account has been taken in the accompanying financial statement of the assets of the Society in the form of publications in stock, with the exception of the cost value, $2735.39, of the copies still in stock of the Joint A.S.T.M.-A.S.M.E. Symposium on Effect of Temperature on the Properties of Metals purchased by the Society from the joint account described in a previous report[1]; this amount is included in the statement of assets. The inventory of technical publications on June 1, 1934, may be summarized approximately as follows:

		NUMBER OF COPIES
Year Book		525
Proceedings		5200
Index to Proceedings	Vols. I–XII, incl	290
	Vols. XIII-XX, incl	340
	Vols. 21–25, incl	315
	Vols. 26–30, incl	310
Book of A.S.T.M. Standards	Part I, Metals	3040
	Part II, Non-Metals	2975
Book of A.S.T.M. Tentative Standards		110
Index to Standards and Tentative Standards		400
Selected Standards for Students in Engineering		....
Selected Standards for Students in Chemistry, Chemical Engineering and Metallurgy		170
Reprints of 471 Standards (approximate)		30 000
Symposium on Effect of Temperature on the Properties of Metals		807
Special Reprints (approximate)		16 000

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 53 (1932).

1934 Finances.—In budgeting Society operations for 1934, the Executive Committee was again faced with considerable uncertainty regarding probable income, although by the end of January when the final draft of the budget was prepared there were encouraging indications that membership losses would be much smaller this year. Accordingly the budget of receipts and disbursements was set up on a tentative basis subject to review and to adjustment of disbursements within actual income, supplemented by such reserve funds as it was felt might be appropriately used if required. The sum of $5700 previously mentioned as available from balances in past years has been tentatively applied to this year's operations. The estimate of current income from dues, namely, $63,400, was based on the assumption of a net loss of membership for the fiscal year of 100 (compared to 420 and 380 for the two preceding fiscal years). It was felt that this was a conservative basis and the developments for the first five months have so far substantiated this. Receipts from sales of publications were estimated at $31,250; miscellaneous receipts were estimated at $9150, bringing the total estimated income for 1934 operations to $109,500.

Disbursements have been tentatively budgeted to this total and provide for all the usual publications and activities of the Society. It was necessary to take due account of slightly increased unit costs of publications. Full provision has been made for the publication of all standards and tentative standards and committee reports. Some curtailment is still necessary respecting the publication of technical papers and discussions and in the volume of preprinting, although conditions this year are more favorable in this respect than a year ago. The reduction in salaries effective from July 1, 1932, has been continued. It has been necessary to keep general office, traveling, committee and meeting expenses to a reasonable minimum. Certain other expenses have increased, the principal item being the rental of the new headquarters.

The Executive Committee will review the entire budget at the annual meeting, at which time income for the year can be predicted with greater certainty and any necessary adjustments in expenditures determined.

Research Fund:

The Executive Committee has given thought this year to the building up of the Research Fund of the Society. As recorded in the preceding section of this report, the principal of the Research Fund comprises $8179.35, to which will be added in due course the sum of approximately $4800 earmarked for the purpose from surplus tentatively set aside for emergency use as previously explained. Under the present plan of adding annually one-half of the entrance fees, the principal of the Research Fund will grow, but slowly. In recent addresses, two of our presidents have emphasized the significance of research to the Society and have pointed out how inadequate are the Society's own funds available for this purpose. K. G. Mackenzie in 1931 and F. O. Clements again in 1932 stressed these matters, and the latter in particular advanced some suggestions looking towards the ultimate establishment of a substantial Fund. Mr. Clements has agreed to head a small special committee consisting of himself, Mr. Mackenzie and H. F. Moore, chairman of Committee E-9 on Research, for the purpose of planning for the upbuilding of this Fund.

Headquarters:

The establishment of new Society headquarters in the Atlantic Building at 260 S. Broad St., Philadelphia, is of course one of the high lights of the year. Descriptions of the new rooms, with plans, have appeared in the Society ***Bulletin***. It will be sufficient in this report to refer briefly to the basic considerations involved in the move.

The quarters in the Engineers' Club Building had been crowded for some years and there was no opportunity for expansion, and the space was inadequate in other respects. Although several promising possibilities were studied in 1932, as mentioned in the report last year, it was felt that the materially increased expense involved in a move at that time was inadvisable. Last fall, however, a proposal was made to the officers of the Society for rental on a five-year lease of space on the fifth floor of the Atlantic Building—one of the finest office buildings in the city, conveniently located to hotels and transportation facilities. The terms offered were both reasonable and within the financial resources of the Society. Examination revealed that excellent headquarters could be established in this space, providing conveniently arranged offices for the staff, an adequate Board Room and—something long needed—a suitable Reception Room and Members' Lounge. Other space on the fourth floor, at a somewhat lower rental, proved suitable for general workroom purposes and for storage of publications. Heretofore it has been necessary, because of lack of fireproof storage facilities at Society headquarters, to store back and current publications in an outside warehouse; this could now be given up, at a net saving in rental costs, together with greater convenience and material saving in time. In every way it appeared desirable to accept the proposal and by unanimous vote of the Executive Committee the officers were authorized to execute a five-year lease ending December 31, 1938. The rooms were ready for occupancy shortly before the end of last year and the headquarters were moved on December 16, 1933.

The new offices comprise 2625 sq. ft. on the fifth floor, devoted to general office purposes, reception, lounge and meeting rooms, and 850 sq. ft. on the fourth floor devoted to storage of publications, mailing and shipping, mimeographing, addressograph and similar work. A Committee on Headquarters, comprising Messrs. G. H. Clamer, T. G. Delbridge, C. N. Forrest, W. H. Fulweiler and G. H. Woodroffe, supervised the decorative treatment of the Reception Room, Members' Lounge and Board Room and the purchase of new furniture, draperies and accessories for these rooms. The total expense involved in the establishment of the new quarters was slightly under $4000, as follows:

Expense of moving and related expenditures having no permanent value		$431.05
Cost of New Furnishings:		
(*a*) Having relatively long life and usable wherever headquarters are established	$3201.33	
(*b*) Having shorter life and probably not usable in other headquarters	356.06	3557.39
		$3988.44

This entire sum will be taken from the Headquarters Fund of $5030 established from surplus some years ago for this purpose[1] and mentioned earlier in the report. Current income, therefore, will not be drawn upon, and there will still be over $1000 in the Headquarters Fund.

The Executive Committee does not consider that this move is necessarily a final solution of the Society's headquarters problem. Rather it is looked upon as one that has greatly improved the "home" of the Society for at least five years at a very reasonable cost. Other possibilities for establishment of a permanent Society home will continue to be studied by the Executive Committee.

Second Exhibit of Testing Apparatus and Equipment:

The Second Exhibit of Testing Apparatus and Equipment, which was held in conjunction with the annual meeting in Chicago last June, of which an account appeared in the July, 1933, *Bulletin*, fulfilled quite well the purposes for which this exhibit was planned. While it was smaller than the first exhibit in 1931, the displays by the nine industrial exhibitors, five Society committees and five research laboratories provided an exceedingly valuable educational feature of the meeting appreciated very fully by the members and committees of the Society. Much new equipment and improvements in older types of equipment were shown by the industrial exhibitors and many important developments in testing were shown by research laboratories and by our committees. Again, the scientific and educational atmosphere was maintained. Thanks of the Society are tendered to all who participated and made this Second Exhibit a success.

---

[1] As noted previously in this report, the sum of $220.87 was paid from the Headquarters Fund during the fiscal year 1933; the balance of $3767.57 was paid in 1934.

In accordance with established policy, no exhibit is being held this year; the Third Exhibit is planned to be held in conjunction with the annual meeting in 1935.

American Standards Association:

The Society's work in the American Standards Association is one of its outstanding cooperative activities. Reference is made to the current report of Committee E-10 on Standards for discussion of the more important happenings in this work. The present report touches only upon some of the more significant developments.

The death of Past-President A. A. Stevenson left a vacancy in the Society's representation upon the A.S.A. Council. Mr. Stevenson had served as a representative of the Society in this movement from its very inception; he was one of an original committee of five members that drafted the articles of organization of the American Engineering Standards Committee—the predecessor of A.S.A. He served as chairman of the A.E.S.C. 1920–1921 and since 1922 he served in the important capacity of liaison member from the A.S.A. on the Planning Committee of the Division of Simplified Practice, Department of Commerce. F. M. Farmer was appointed to fill Mr. Stevenson's unexpired term; J. A. Capp has been reappointed as a member of the Council for the ensuing three years and the Assistant Secretary of the Society serves as alternate. Mr. Farmer has recently been elected vice-chairman of the Standards Council.

On invitation by the Standards Association, the Society nominated Mr. Quincy Bent, Vice-President of the Bethlehem Steel Co., as a member of the A.S.A. Board of Directors. Mr. Bent was subsequently elected and will serve on the Board for a term of three years.

In March, 1934, there was organized under the sponsorship of the Society a Sectional Committee on Electrical Insulating Materials, which will serve the two-fold purpose of coordinating the work of the several A.S.T.M. committees that deal with these materials and providing means of contact with other associations that have major interest in tests and specifications for these materials. An account of the organization of the committee and its personnel appeared in the March, 1934, *Bulletin.*

The Society has recently proposed the establishment under the procedure of the American Standards Association of a standardization project defined by the following tentative statement of scope and the organization under A.S.T.M. sponsorship of a sectional committee for carrying out the project:

> Specifications, methods of test and nomenclature relating to crude petroleum and petroleum products, including lubricants containing petroleum products; but excluding specifications, methods of test and nomenclature relating to petroleum products used as road, paving or waterproofing materials, or relating to organic chemicals or to products used medicinally.

This proposal has come about through the study of present and future standardization problems in this field and the need, as the Society views it, of setting up a single representative committee to undertake the orderly systematic development of this work that is afforded by the procedure of the A.S.A. The proposal is now being studied by the Standards Association.

After many months of planning, a program of cooperation between the American Standards Association and the National Bureau of Standards has been announced that comprises the work on simplification, commercial standards, safety codes and building and plumbing codes heretofore carried on under the sole auspices of the Bureau. Details of the plan are set forth in the March, 1934, issue of *Industrial Standardization and Commercial Standards Monthly.* Briefly, the simplification and commercial standards work will be carried on jointly by the A.S.A. and the Bureau of Standards, following in principle the same procedure heretofore followed by the Bureau, although simplified practices and commercial standards hereafter developed will also be transmitted to the Standards Council of the A.S.A. for its consideration. The Bureau will continue its rôle in the program of national safety codes, which has been developed under the procedure of the A.S.A. for a number of years. The building and plumbing code work formerly carried on, since 1921, by the Department of Commerce through its Building Code Committee and the Subcommittee on Plumbing, has been placed directly under A.S.A. auspices, with the expectation that it will be developed under a procedure similar to that followed for the development of safety codes.

The A.S.T.M. is directly interested in a number of the commercial standards projects and certain phases of the building and plumbing code work and will be in a position through its membership in the

A.S.A. to assist in the development of these projects in so far as specifications and tests for materials are concerned.

International Cooperation:

The Society is participating in the work of several technical committees of the International Standards Association, having provided through the A.S.A. the American representation on the following three committees: Nomenclature and Methods of Test of Petroleum Products, of which this country holds the secretariat; Sieves for Testing Purposes; and Methods of Sampling and Analysis of Coal. The following I.S.A. projects in which our Society may have more or less interest have either been organized through committees or have been proposed: Pipe and Fittings; Soil Pipe; Iron and Steel; Cast Iron and Cast Steel; Bronze, Brass, etc.; Refractories; Paints. It seems advisable for the Society through its appropriate standing committees to maintain a measure of contact with I.S.A. committees that are doing any work in our field and this matter is being taken up with the appropriate committees of the Society and with the American Standards Association.

In the International Association for Testing Materials progress is being made in the study commissions mentioned in the report a year ago. The Society is represented on nine of these commissions dealing with the following subjects: Density, Frost and Weather Resistance of Concrete; Deformation of Reinforced Concrete; Sampling and Analysis of Fuels; Terminology of Mechanical Properties; Elasticity; Viscosity; Cast Iron; Wood; Uniformity in Calibration of Testing Apparatus. The program for the next Congress of the I.A.T.M. is now being developed and several standing committees of the Society have been asked to make suggestions on subjects that might well be discussed internationally and suitable reporters who could set forth the American viewpoint with respect to these subjects.

The International Association suffered a severe loss in the death of its President, Dr. Walter Rosenhain, F.R.S., who had been president since 1931.

W. H. Fulweiler, American Member of the Permanent Committee, I.A.T.M., has been elected to the Vice-Presidency of the Association.

The Society was represented by Messrs. R. P. Anderson and A. W. Pope, Jr., at the World Petroleum Congress held in London, July, 1933. One outcome of the Congress of immediate interest to the Society was the progress made in the work of the I.S.A. Committee on Nomenclature and Methods of Testing Petroleum Products mentioned above.

Another interesting development from this Congress is the institution of cooperative work between the Society and the Road Emulsion and Cold Bituminous Roads Association of England on the subject of tests for emulsified asphalt for road purposes. Other nations that are cooperating in this work through their appropriate organizations are: France, Germany and Italy. This work is being done for the Society under the immediate direction of Committee D-4 on Road and Paving Materials.

Contacts with National Recovery Activities:

Early last summer the Executive Committee offered the assistance of the Society to both the Public Works and National Recovery Administrations. The functions and activities of the Society, its accomplishments in the standardization of specifications and tests, and the facilities available for development of standards were explained to officials of the Administration. At that time the public works program was just being formulated and the assistance of A.S.T.M. was tendered to the Public Works Administration in connection with the development and use of specifications and tests for materials used in that work. A set of A.S.T.M. Standards and Tentative Standards was furnished to each State Engineer of Public Works and to several key officials of the Administration. There is no means of knowing just how useful this has been in the administration of the public works program, although appreciative acknowledgments were received from practically all these officials, many revealing a definite knowledge of A.S.T.M. standards and intention to use or adapt them wherever possible.

From the inception of the development of Codes of Fair Competition under the N.R.A., the Executive Committee has recognized that the question of standards for quality of materials would probably require consideration in many industries, directly in the Codes themselves or in some other form depending upon conditions that might readily differ in different industries. Contacts last summer with N.R.A. officials made clear then what has been subsequently borne out, that for some months the Recovery Administration would be concerned primarily with wage and labor problems and that little attention could be given to standards of quality. There have been scattered references to such standards in the N.R.A. codes so far promulgated, including references to a number of A.S.T.M. standards. In recent months, there has been increasing emphasis upon standards in their relation to the codes and code administration, especially as concerns so-called "ultimate consumer goods," and conferences upon this subject have been held under the auspices of the Consumers Advisory Board and the Division of Industrial Planning and Research, in which the Society has participated upon invitation. There are various ways in which the Society can cooperate with the proper authorities in the development of standards under the N.R.A. codes; such cooperation, having already been offered to the National Recovery Administration, is also being extended to the Code Authorities for those industries that are presumably concerned with the field of work covered by the Society. The Society's nearly 700 standards and tentative standards, nationally recognized and widely used, are peculiarly suited for consideration in this connection, since they represent the combined judgment of producer and consumer of materials. Unquestionably these standards may effectively be used if and when quality standards for materials are to be developed under code procedure.

Respectfully submitted on behalf of the Executive Committee,

T. R. LAWSON,
President.

C. L. WARWICK,
Secretary-Treasurer.

June, 1934.

REPORT OF COMMITTEE A-1
ON
STEEL

Committee A-1 on Steel has held two meetings during the past year: at Chicago, on June 26, 1933, and at Washington, D. C., on March 7, 1934. A large attendance was recorded at each of these meetings and with many subcommittees meeting in conjunction with the main committee, notable progress was made in the work of the committee. The stated January meeting of Committee A-1 has been suspended during the past two years because of the economic conditions, but due to the large number of meetings of subcommittees and their subgroups that are now required, and the increasing program of work, it may be necessary to resume the January meeting.

Three of the subcommittees have elected new chairmen for the term 1934–1936: Subcommittee III on Structural Steel for Ships, R. M. Watt; Subcommittee IX on Steel Tubing and Pipe, T. G. Stitt; and Subcommittee XXI on Steel for Welding, N. L. Mochel. Other subcommittees have reelected the present chairmen.

Since the 1933 annual meeting, 6 new members have been elected, and 4 resignations accepted, the committee now having a total membership of 187, of whom 104 are classified as non-producers, and 83 as producers. Of the former, 79 are consumer and 25 general interest members.

Tentative Standards Issued During the Past Year:

Four proposed tentative standards were submitted by Committee A-1 during the past year to the Society through Committee E-10 on Standards. The first[1] of these, listed below, was accepted for publication as tentative on August 16, 1933, the last three[2] being issued on October 30, 1933:

Tentative Specifications for Carbon-Steel Castings for Industrial, Railroad and Marine Uses (A 154 – 33 T)
Tentative Specifications for Steel for Bridges (A 7 – 33 T)

---

[1] In submitting these tentative specifications to Committee E-10 on Standards, Committee A-1 reported results of the letter ballot vote as follows: Of a total membership of 186, 120 members returned their ballots, of whom 83 voted affirmatively and 1 negatively.

[2] In submitting these tentative specifications to Committee E-10 on Standards, the committee reported the following results of the letter ballot vote of a total of 138 ballots returned from a committee membership of 186: Tentative Specifications for Steel for Bridges (A 7 – 33 T), 97 affirmative and 1 negative; Tentative Specifications for Steel for Buildings (A 9 – 33 T), 99 affirmative and none negative; Tentative Specifications for Mild Steel Plates (A 10 – 33 T), 94 affirmative and 1 negative.

Tentative Specifications for Steel for Buildings (A 9 – 33 T)
Tentative Specifications for Mild Steel Plates (A 10 – 33 T)

For reasons discussed below, the Tentative Specifications for Structural Medium Steel (A 140 – 32 T) were withdrawn when the last three specifications listed were issued. The four new tentative standards which appear in the 1933 *Proceedings*[1] are of much importance and mark the completion of extensive preliminary work on the part of the two subcommittees in charge.

The Tentative Specifications for Carbon-Steel Castings for Industrial, Railroad and Marine Uses (A 154 – 33 T) were prepared under the direction of Subcommittee VIII on Steel Castings (W. C. Hamilton, chairman), the actual work being done by a special committee headed by R. A. Bull. This special committee was so constituted as to be representative of the various producing and consuming interests and included representatives of organizations interested in steel castings, such as the American Railway Association, Steel Founders' Society of America, American Foundrymen's Association, U. S. Navy, etc. Since existing standard specifications for carbon-steel castings contain divergent requirements for identical grades of steel and because manufacturing progress had advanced beyond the point indicated by current requirements, new specifications were urgently needed. It was decided to draft a consolidated specification which ultimately could entirely supersede the Standard Specifications for Carbon-Steel Castings (A 27 – 24) and the Standard Specifications for Carbon-Steel Castings for Railroads (A 87 – 27). Since the former contain a supplement covering ship castings, an additional supplement applying exclusively to railroad castings was developed and in the body of the new specifications were put all general clauses that apply to industrial, railroad and marine applications. The committee urged the approval of the specifications as representing the most satisfactory present basis for harmonizing differences of opinion held by informed persons regarding proper purchase requirements for the material.

The Tentative Specifications for Steel for Bridges (A 7 – 33 T), Steel for Buildings (A 9 – 33 T) and Mild Steel Plates (A 10 – 33 T) were developed by Subcommittee II on Structural Steel for Bridges, Buildings and Rolling Stock (A. W. Carpenter, chairman). When the Tentative Specifications for Structural Medium Steel (A 140 – 32 T) were issued in 1932, covering a grade of steel with the required tensile range of 60,000 to 72,000 lb. per sq. in., it was expected that they would eventually supersede the Standard Specifications for

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 544, 511, 519, 526 (1933); **also** 1933 Book of A.S.T.M. Tentative Standards, pp. 38, 1, 9, 16.

Structural Steel for Bridges (A 7 – 33) and Structural Steel for Buildings (A 9 – 33). This idea, however, met with two principal objections: the elimination of a specification for a 55,000 to 65,000 lb. per sq. in. tensile strength grade for certain plate uses and the elimination of bessemer steel for building purposes. Since many railroad interests, steel fabricators, highway departments and building codes were adopting the so-called medium grade of steel, the need for new specifications was evident. After careful consideration, the various interests represented in Subcommittee II approved the plan of revising Specifications A 7 and A 9 to cover medium steel and to write separate specifications to cover the softer grade of plates. In offering the proposed specifications as tentative, the subcommittee and Committee A-1 intended in regular course of Society procedure to recommend their adoption as standard, to supersede the respective existing standards (see report of Subcommittee II).

RECOMMENDATIONS AFFECTING STANDARDS

The many recommendations of the committee affecting the standard and tentative specifications are listed first in summarized form for convenience together with an analysis of the letter ballot on each item. Where necessary, these recommendations are referred to further, being grouped for convenience in the order of the subcommittees responsible for them.

I. Proposed Tentative Standard.—The committee recommends that the proposed Tentative Specifications for Electric-Fusion-Welded Steel Pipe for High-Temperature and High-Pressure Service be accepted for publication as tentative, as appended hereto.[1]

II. Proposed Revisions of Standards.—The committee recommends that revisions, as given in the Appendix to this report, of the twelve standard specifications listed below be published as tentative for one year before referring them to letter ballot of the Society for adoption:

Standard Specifications for Open-Hearth Carbon-Steel Rails (A 1 – 30)
Standard Specifications for Boiler Rivet Steel and Rivets (A 31 – 24)
Standard Specifications for Structural Rivet Steel (A 141 – 33)
Standard Specifications for Structural Steel for Ships (A 131 – 33)[2]
Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 33)
Standard Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 – 33)
Standard Specifications for Carbon-Steel Car and Tender Axles (A 21 – 27)
Standard Specifications for Wrought Solid Carbon-Steel Wheels for Electric Railway Service (A 25 – 24)
Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 33)[2]

---

[1] See p. 628.—ED.

[2] Subsequent to the annual meeting Committee A-1 on Steel presented to the Society through Committee E-10 on Standards additional revisions of these specifications, see Editorial Note, p. 74.—ED.

Standard Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 33)[1]
Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 33)[1]
Standard Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 33)[1]

III. Proposed Revisions of Tentative Standards.—The committee recommends that the following tentative specifications be revised as indicated, and the revised specifications be continued as tentative:

Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 32 T), extensively revised as appended hereto[2]
Tentative Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139 – 32 T), revised as proposed in the Appendix
Tentative Specifications for Cold-Rolled Strip Steel (A 109 – 27 T), extensively revised as appended hereto[3]
Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 33 T), revised as proposed in the Appendix[1]

IV. Adoption of Tentative Standards as Standard.—The committee recommends that the following four tentative specifications[4] be referred to letter ballot of the Society for adoption as standard:

Tentative Specifications for Electric-Resistance-Welded Steel Pipe (A 135 – 32 T)
Tentative Specifications for Forge-Welded Steel Pipe (A 136 – 32 T), revised as proposed in the Appendix
Tentative Specifications for Lock-Bar Steel Pipe (A 137 – 32 T)
Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 32 T)

The committee asks for the necessary nine-tenths vote at the annual meeting in order that the three tentative specifications,[5] listed below, approved for publication as tentative by Committee E-10 on Standards on October 30, 1933, may be submitted to letter ballot of the Society for adoption as standard, without revision:

Tentative Specifications for Steel for Bridges (A 7 – 33 T)
Tentative Specifications for Steel for Buildings (A 9 – 33 T)
Tentative Specifications for Mild Steel Plates (A 10 – 33 T)

---

[1] Subsequent to the annual meeting Committee A-1 on Steel presented to the Society through Committee E-10 on Standards additional revisions of these specifications, see Editorial Note, p. 74.—ED.

[2] See p. 604.—ED.

[3] See p. 591.—ED.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 570, 576, 581, 586 (1932); also 1933 Book of A.S.T.M. Tentative Standards, pp. 91, 97, 102, 107.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 511, 519, 526 (1933); also 1933 Book of A.S.T.M. Tentative Standards, pp. 1, 9, 16.

V. Adoption of Tentative Revisions of Standards as Standard.—The committee recommends that the tentative revisions proposed last year in the following standards be submitted to the Society for adoption as standard:

Revision of Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 33)[1]

Revision of Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 33)[1]

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Specifications for Electric-Fusion-Welded Steel Pipe for High-Temperature and High-Pressure Service	62	1	59
II. PROPOSED REVISIONS OF STANDARDS			
Specifications for Open-Hearth Carbon-Steel Rails (A 1 – 30)	57	0	65
Specifications for Boiler Rivet Steel and Rivets (A 31 – 24)	72	5	45
Specifications for Structural Rivet Steel (A 141 – 33)	81	1	40
Specifications for Structural Steel for Ships (A 131 – 33)	67	2	53
Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 33)	65	2	55
Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 – 33)	61	2	59
Specifications for Carbon-Steel Car and Tender Axles (A 21 – 27)	62	2	58
Specifications for Wrought Solid Carbon-Steel Wheels for Electric Railway Service (A 25 – 24)	52	0	70
Specifications for Welded and Seamless Steel Pipe (A 53 – 33)	73	1	48
Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 33)	61	2	59
Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 33)	64	6	53
Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 33)	58	1	63
III. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 32 T)	66	1	55
Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139 – 32 T)	66	0	56
Specifications for Cold-Rolled Strip Steel (A 109 – 27 T)	57	1	64
Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 33 T)	64	5	53
IV. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications for Electric-Resistance-Welded Steel Pipe (A 135 – 32 T)	64	1	57
Specifications for Forge-Welded Steel Pipe (A 136 – 32 T), as revised	66	0	56
Specifications for Lock-Bar Steel Pipe (A 137 – 32 T)	66	1	55
Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 32 T)	66	1	55
Specifications for Steel for Bridges (A 7 – 33 T), immediate adoption	73	3	46
Specifications for Steel for Buildings (A 9 – 33 T), immediate adoption	76	2	44
Specifications for Mild Steel Plates (A 10 – 33 T), immediate adoption	79	2	41
V. ADOPTION OF TENTATIVE REVISIONS OF STANDARDS AS STANDARD			
Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 33)	60	0	62
Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 33)	69	0	53
VI. WITHDRAWAL OF STANDARDS AND TENTATIVE STANDARD			
Standard Specifications for Structural Steel for Bridges (A 7 – 33)	73	3	46
Standard Specifications for Structural Steel for Buildings (A 9 – 33)	76	2	44
Tentative Specifications for Electric Cast-Steel Stud-Link Anchor Chain (A 77 – 28 T)	57	0	65

VI. Withdrawal of Standards and Tentative Standard.—Committee A-1 recommends that concurrently with the adoption as standard of the two existing tentative specifications covering bridge and building steel, as recommended earlier in this report, the Standard Specifications for Structural Steel for Bridges (A 7 – 33)[1] and for Structural Steel for Buildings (A 9 – 33)[1] be withdrawn.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 1028 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 1066.

The withdrawal is also recommended of the Tentative Specifications for Electric Cast-Steel Stud-Link Anchor Chain (A 77 – 28 T).[2] These specifications, placed under the jurisdiction of Subcommittee VIII on Steel Castings in 1933, cover a material the use of which no longer justifies their continuance, and the few organizations which have manufactured material under them have no objection to their withdrawal.

The recommendations appearing in this report have been referred to letter ballot of the committee, which consists of 187 members, with the results shown in Table I.

ACTIVITIES OF SUBCOMMITTEES AND SPECIAL COMMITTEES

The recommendations previously listed, as well as the other features of the committee's work, are discussed below grouped in the order of the respective subcommittees responsible.

The three subcommittees respectively in charge of the Standard Specifications for Structural Rivet Steel (A 141 – 33), Structural Steel for Ships (A 131 – 33) and Boiler Rivet Steel and Rivets (A 31 – 24) are proposing tentative revisions as given in the Appendix, affecting the sulfur requirements of the rivet material. These changes will simplify obtaining the grades of rivet steel at no sacrifice of any safeguards to the purchaser.

Fact Finding Committee on Consolidation of Rivet Specifications (Jonathan Jones, chairman).—This special committee was appointed in 1933 to study the possibilities of consolidating existing rivet specifications, with a reduction in the number of grades required. Based on a meeting of the special committee, considerable correspondence, and a combined meeting of Subcommittees II, III, and XI, whose representatives comprised the Fact Finding Committee, the committee concluded: (1) It appears that at present there is no possibility of reducing the three present grades of rivet steel to two by eliminating or modifying one of the grades; (2) In view of this it does not seem advisable to combine the several specifications into one document: (3) Since the study cannot be profitably carried further at this time, the committee should be discharged.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, pp. 1, 8.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 702 (1928); also 1933 Book of A.S.T.M. Tentative Standards, p. 53.

Subcommittee I on Steel Rails and Accessories (E. F. Kenney, chairman).—The revisions in the Standard Specifications for Open-Hearth Carbon-Steel Rails (A 1 – 30), as given in the Appendix, are recommended by this subcommittee to make them more acceptable to domestic railroads and to foreign buyers. Many of the latter use the A.S.T.M. standard in preference to foreign specifications.

In view of the extensive use of A.S.T.M. specifications for rails and fastenings, Subcommittee I suggests the advisability of the Society issuing a pamphlet containing a compilation of these specifications. It is the belief that such a convenient pamphlet would be used by both manufacturers and consuming interests and would further extend the use of the specifications.

Subcommittee II on Structural Steel for Bridges, Buildings and Rolling Stock (A. W. Carpenter, chairman).—In recommending the adoption as standard of the existing Tentative Specifications for Steel for Bridges (A 7 – 33 T), Steel for Buildings (A 9 – 33 T), and Mild Steel Plates (A 10 – 33 T) and the concurrent withdrawal of the existing Standard Specifications for Structural Steel for Bridges (A 7 – 33), and for Structural Steel for Buildings (A 9 – 33), the committee is acting consistently with its program announced when the tentative specifications were offered to the Society. The rapidly increasing use of the so-called medium grade of structural steel justifies this action.

The subgroup working on specifications for high-strength rivet steels (Jonathan Jones, chairman) has sponsored considerable test work and has conferred with bureaus of the U. S. Navy which make extensive use of this grade of steel. As a result, proposed specifications have been drafted and circulated among the subcommittee and the members of Subcommittees III on Structural Steel for Ships, and XI on Boiler Steel, which subcommittees are also interested. After further study it is hoped action can be taken on the proposals.

Subcommittee III on Structural Steel for Ships (R. C. Davis, chairman).—Since principal users of the grade of material covered in the Standard Specifications for Structural Steel for Ships (A 131 – 33) do not require tension tests on thin material, the subcommittee proposes a revision as given in the Appendix, eliminating such tests. This is in line with requirements of other specifications for structural steel, written by Committee A-1.

Subcommittee V on Steel Reinforcement Bars (H. H. Morgan, chairman).—Although the Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 33) and for Rail-Steel Concrete Reinforcement Bars (A 16 – 33) were extensively revised in 1933, certain additional proposed changes, as given in the Appendix, are being submitted for publication as tentative revisions. These provide additional requirements for permissible maximum weight variations for individual bars: 6 per cent under theoretical weight for bars $\frac{3}{8}$ in. and larger, 10 per cent under for bars less than $\frac{3}{8}$ in. These individual bar requirements were adopted after thorough discussion at a meeting attended by representatives of numerous consuming groups, with state and Federal departments represented. Some discussion had previously been given to a proposed permissible lot variation of 2.5 per cent under and 7.5 per cent over theoretical weight, but, after careful consideration, it was agreed that the recently established tolerance of 3.5 per cent over or under not only represented closer over-all variation limits, but as a balanced tolerance was more suitable to practical considerations in production and should, therefore, remain the standard requirement for lots. With the proposed revisions covering individual bars, it is believed that the two reinforcing bar standards represent complete agreement of all interested groups, both consuming and producing.

Since no criticism has been received of existing tentative revisions in the Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 33) giving yield point requirements and method of determination, and clarifying permissible variations in gage, it is proposed they be adopted as standard.

Subcommittee VI on Steel Forgings and Billets (R. W. Steigerwalt, chairman).—This subcommittee recommends tentative revisions of the Standard Specifications for Carbon-Steel Car and Tender Axles (A 21 – 27), as given in the Appendix. These specifications cover tapered axles for drop test requirements, and an added footnote will refer to axles with parallel sides. Proposed changes in manganese requirements are to bring the specifications in line with other forging standards, so that the same grades of steel can be used. Because it may be an injustice to require the purchaser to pay for a test axle on small orders, a provision modifying the clause covering number of tests is recommended.

This subcommittee is studying the possibility of combining requirements for various carbon-steel forgings now covered in separate specifications. Also under way is an investigation of the requirements for alloy-steel forgings as given in the various A.S.T.M. specifications sponsored by the committee.

Subcommittee VII on Rolled Steel Wheels and Steel Tires (R. W. Steigerwalt, chairman).—Since the Standard Specifications for Wrought Solid Carbon-Steel Wheels for Electric Railway Service (A 25 – 24) were adopted, improvements in production have been made which merit beneficial changes in certain requirements. Also, it is considered desirable to work to a closer range in the variation of flange and rim tolerances for wheels used on grooved rails and since no distinction heretofore has been made in variations between usage on grooved rails or on T-rails, modifications of the permissible variations are deemed desirable. It will be noted from the changes as given in the Appendix that manganese and silicon ranges have been raised and two sets of tolerances for wheels are specified: one set for wheels used on grooved rails and the greater tolerance for wheels used on T-rails.

Those sections of the Standard Specifications for Steel Tires (A 26 – 16) covering chemical composition and permissible variations are being studied, since changes are necessary. The Specifications Committee of the American Railway Association is being conferred with in an effort to harmonize the requirements.

Subcommittee IX on Steel Tubing and Pipe (H. H. Morgan, chairman).—Because there have been persistent requests stressing the necessity of incorporating galvanizing requirements in the Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 32 T), these specifications have been revised as appended hereto[1] and are recommended for continuation as tentative in their revised form.

So that galvanized pipe may be purchased under the requirements of the Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 33), a note as shown in the Appendix is recommended as a tentative revision.

In recommending the adoption as standard of the four specifications, listed earlier in this report, covering various types of fabricated pipe, the committee recognizes that they have been tentative for two years and all criticism received on them has been taken care of. Three of these specifications cover products that have been manufactured and in use for many years, while the fourth, namely, the Tentative Specifications for Electric-Resistance-Welded Steel Pipe (A 135 – 32 T) covers special products of two large manufacturers, who have for several years furnished substantial tonnages to the specifications. A revision, as given in the Appendix, is recommended for the holding-time of the hydrostatic test pressure in the Tentative Specifications for Forge-Welded Steel Pipe (A 136 – 32 T).

Revisions, as given in the Appendix, are recommended in the Tentative Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139 – 32 T), clarifying the requirements for weld metal projection and providing slightly increased tolerances for thin wall material, which are desirable.

---

[1] See p. 604.—ED.

This subcommittee is initiating a study of the free bend test in relation particularly to the weld metal of pipe specifications. The tentative revision issued in 1933 of the Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 33) involving the marking clause is recommended for adoption as standard.

Subcommittee XI on Boiler Steel (E. J. Edwards, chairman).—This subcommittee has drafted a consolidation of the Standard Specifications for Boiler and Firebox Steel for Stationary Service (A 70 – 33) and Standard Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 – 33) which has been referred to Subcommittee XXI on Steel for Welding for study. The subcommittee is working also on a consolidation of the Tentative Specifications for High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates 2 in. and under in Thickness) (A 149 – 33 T) and the Tentative Specifications for High Tensile Strength Carbon-Steel Plates for Fusion-Welded Pressure Vessels (Plates over 2 in. up to and Including 4 in. in Thickness) (A 150 – 33 T).

Subcommittee XIX on Sheet Steel and Steel Sheets (A. L. Davis, chairman).—This subcommittee has been working intensively on revisions in the Tentative Specifications for Cold-Rolled Strip Steel (A 109 – 27 T) in order to meet objections to certain provisions in the specifications and to make them of distinct practical value. The revised specifications, as appended hereto,[1] are recommended for publication as tentative. Important changes in the specifications include: (1) Removal of the table of physical properties from the body of the specification, and affixing it as an appendix in considerably amplified form; (2) revision of the table of gage tolerances to bring them in line with N.R.A. code tolerances; (3) reference to the standard tension test specimen for sheet metals specified in the Standard Methods of Tension Testing of Metallic Materials (E 8 – 33); (4) improvements in phraseology, with the addition of a generally descriptive preamble including data on the demarcation between cold-rolled sheets and cold-rolled strip steel, and a paragraph relating to age hardening and stretcher strains.

Subcommittee XXI on Steel for Welding (F. N. Speller, chairman).—This subcommittee has been in touch with representatives of the American Bureau of Welding (sponsored jointly by the American Welding Society and the National Research Council) in the formulation of specifications for filler metal for use in fusion welding, a special joint group having been organized for this purpose. The Bureau has issued tentative specifications as information and for comment, and Subcommittee XXI expects shortly to recommend these specifications to Committee A-1 for approval as tentative.

---

[1] See p. 591.—ED.

At the request of Subcommittee XXII the committee is studying the influence of manganese on fusion welding and whether manganese as well as carbon should be limited where A.S.T.M. specifications are used for purchasing material for fusion welding.

Subcommittee XXII on Valves, Fittings, Piping and Flanges for High-Temperature Service (A. E. White, chairman).—This committee recommends for approval as tentative the proposed Specifications for Electric-Fusion-Welded Steel Pipe for High-Temperature and High-Pressure Service, as appended hereto.[1] The need for these specifications was brought to the attention of the committee by a large producer of fusion-welded steel pipe. This pipe was being used for high-temperature and high-pressure service and although there are not many fabricators of this pipe, Subcommittee XXII feels that the specifications are desirable in order that the material may be purchased in accordance with proper specification requirements. The need for specifications covering Class I fusion-welded pipe was recognized in drafting the code for pressure piping (A.S.A. Project B31) and provision has been made therein for referring to such specifications when approved by the A.S.T.M.

The proposed tentative revision[2] of the pressure-temperature tables in the Standard Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 33), for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 33), for Forged or Rolled Steel Pipe Flanges for High-Temperature Service, and the Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 33 T) are the outgrowth of the agreement reached at the open meeting of Subcommittee 4 of Sectional Committee B16 on Pipe Flanges and Fittings, held last December. Representatives of the oil industry, Sectional Committee B16, the power industry, and the A.S.M.E. Boiler Code Committee and Subcommittee XXII and others attended this meeting. These ratings satisfy the objections, particularly of the oil industry and the Boiler Code Committee, to the ratings now appearing in the specifications.

A tentative revision in the Standard Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 33) providing deletion of requirements for Class A flanges is recommended for these reasons: (1) it is impossible to obtain steel having the physical properties specified with the low-carbon content required for forge welding; (2) there is no call for such flanges since they have been supplanted by welding-neck flanges attached to the pipe by fusion welding.

---

[1] See p. 628.—ED.

[2] In addition to the tentative revisions referred to here, further changes in these specifications were presented by Committee A-1 on Steel to the Society through Committee E-10 on Standards subsequent to the annual meeting, see Editorial Note, p. 74.—ED.

Because of trouble experienced with splitting of nuts made from bar stock, a tentative revision, as given in the Appendix, calling for the exclusion of such nuts is proposed in the Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 33).

Existing elongation requirements in the Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 33 T) have been criticized by users of this material. The revised figures proposed in a tentative revision, see Appendix, are a compromise, being acceptable to the producers and considered satisfactory to those consumers who have objected to the lower figures.

Subcommittee XXII has been working intensively on the preparation of specifications for materials to be used at temperatures of 750 to 1100 F. (400 to 590 C.).[1] Drafts of such specifications have been extensively discussed at the meetings of this subcommittee and its four sections in New York (December) and Washington (March). As a result, it has been decided to incorporate more informatory data in the section which would list high-temperature characteristics of metals. The Joint Research Committee of the A.S.M.E. and A.S.T.M. on Effect of Temperature on the Properties of Metals will cooperate with Subcommittee XXII in this work.

The subcommittee is making definite progress on specifications for carbon-steel nuts suitable for steam-service temperatures up to 850 F. (450 C.) and hopes to submit these to Committee A-1 in the near future.

Losses by Death:

During the year, Committee A-1 has lost by death three members who were active in its work, Messrs. C. E. Chase, J. H. Gibboney and A. A. Stevenson, the latter two, Past-Presidents of the Society. In addition, T. D. Lynch, a former active member and an A.S.T.M. Past-President, passed away. Committee A-1 wishes to record its appreciation of their generous help and counsel so unselfishly given.

---

[1] Subsequent to the annual meeting Committee A-1 presented to the Society through Committee E-10 on Standards new Tentative Specifications for Alloy-Steel Castings for Valves, Flanges and Fittings for Service at Temperatures from 750 to 1100 F. and Specifications for Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F., which were accepted for publication as tentative, see Editorial Note, p. 74.—ED.

One of these men had been a member since the committee's organization, an officer, and chairman of two important subcommittees. Because, in addition, there is attributed to his early efforts more than to any other's, much of the success of its work, the committee wishes to pay tribute to his memory. The following resolution, prepared by a special committee of A-1 members, who were privileged to know him intimately, consisting of L. H. Fry, F. E. Schmitt and C. L. Warwick, chairman, was adopted at the March meeting:

RESOLUTION ON DEATH OF ARCHIBALD ALSTON STEVENSON

Adopted by Committee A-1 on Steel, March 7, 1934

In the death of Archibald Alston Stevenson, Committee A-1 on Steel of the American Society for Testing Materials loses a member who made history for the committee. He helped clear the ground and held the plumb and the square for the foundations of many of the specifications which have served the steel industry for nearly twenty years.

In the two or three years following 1913 the steel specifications were being modernized and developed. Manufacturers and consumers were vitally interested, and there were many honestly conceived and firmly held differences of opinion. To establish workable specifications, it was essential that opposing views should be reconciled. Stevenson found ample scope for his wonderful ability as a mediator. He foresaw the value to industry of stable workable specifications and strove untiringly to guide their construction and to secure their adoption. It was largely due to him that the important steel specifications, used today without fundamental changes, were adopted by subcommittees, by Committee A-1 and by the Society, with practical unanimity.

The great influence he wielded was based on universal recognition of his fairness. If Stevenson stood back of a proposal, everyone who knew him knew that the proposal was just and straightforward. Before he sponsored a measure it was most scrupulously analyzed. It must be grounded in justice—and if it leaned in either direction, it must favor his opponents.

Besides holding the complete confidence of the whole committee, Stevenson had a canny knowledge of the human element involved in committee work, which was supported and guided by a high degree of technical understanding and intuitive penetration to the heart of a problem. He was indefatigable in getting the point of view of all sides interested in a question and in trying to adjust differences of opinion before these led to discussion on the floor. His major work was done before the specifications came up for discussion on the floor of the meeting. One could, however, be sure that if a snarl arose on the floor and impassioned oratory threatened, Archie would rise from the second row on the left and would tell, probably, a humorous story to break the tension and bring harmony. In an extreme case an adjournment would be moved, and Stevenson would work intensively and effectively to find a proper meeting ground for opposing views. He did not lobby so that a fixed view might prevail. He looked for a just and equitable solution to resolve differences of opinion. If one member of a committee conscientiously objected to a proposal otherwise acceptable, he could count on Stevenson's support in his call for justice. One might have called

Stevenson the protector of minorities, but with him at work, there were no minorities. He saw to it that specifications were accepted unanimously or not at all.

As a chairman he was extremely effective. He held the scales level and generally at the end of a discussion would sum up the situation and ask for a motion to that effect. An admiring critic once said that Archie was a most unparliamentary chairman, as about eighty-nine per cent of the motions were made by the chair!

Stevenson's official connection with Committee A-1 was extensive. He served as vice-chairman in 1911 and 1912. He was, in the early days of the committee, chairman of the group on tires and Subcommittee VII on Wheels and Tires was formed under his chairmanship. He held this post up to 1926. Much of his more valuable work for Committee A-1 was done as chairman of Subcommittee VI on Forgings during the years 1914 to 1916. This was a most active period for this subcommittee and the ground covered by it was greatly extended.

Remarkable testimony to the universal recognition of his fairness and ability as a mediator was given when he was conscripted for the chair of Subcommittee XX on Plate Tolerances. This committee was set up to attempt the impossible task of harmonizing irreconcilable viewpoints on permissible variations in plate dimensions. Stevenson had no direct interest in either the production or use of steel plate. The committee wanted him as chairman because they knew the difficulty of their appointed work. They felt that in Stevenson's guidance lay their only hope of harmony.

In Archie Stevenson Committee A-1 has lost a member who did much for the committee and for the Society, and who was able to do this not only because of the unstinted time and energy that he gave, but because of the admiration, affection and esteem in which he was held. The committee extends its sincerest sympathies to the members of his family.

The election of officers resulted in the re-election of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee which consists of 187 members; 108 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. H. MORGAN,
Chairman.

H. P. BIGLER,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Electric-Fusion-Welded Steel Pipe for High-Temperature and High-Pressure Service were accepted for publication as tentative and appear on page 628.

The proposed revisions of the Standard Specifications for Open-Hearth Carbon-Steel Rails, for Boiler Rivet Steel and Rivets, for Structural Rivet Steel, for Structural Steel for Ships, for Billet-Steel Concrete Reinforcement Bars, for Rail-Steel Concrete Reinforcement Bars, for Carbon-Steel Car and Tender Axles, for Wrought Solid Carbon-Steel Wheels for Electric Railway

Service, for Welded and Seamless Steel Pipe, for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service, for Alloy-Steel Bolting Material for High-Temperature Service, and for Forged or Rolled Steel Pipe Flanges for High-Temperature Service were accepted for publication as tentative and appear on pages **1249** to **1257**, inclusive.

The revisions of the Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses, for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.), for Cold-Rolled Strip Steel, and for Lap-Welded and Seamless Steel Pipe for High-Temperature Service were accepted. The specifications in their revised form appear on pages **604**, **598**, **591** and **637**, respectively.

The Tentative Specifications for Electric-Resistance-Welded Steel Pipe, for Lock-Bar Steel Pipe, for Riveted Steel and Wrought-Iron Pipe and for Forge-Welded Steel Pipe, the latter revised on the floor of the annual meeting, see Summary of Proceedings, page 5, were approved and subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 34 to 52, inclusive.

The immediate adoption as standard of the Tentative Specifications for Steel for Bridges, for Steel for Buildings, and for Mild Steel Plates, which specifications replace the existing Standard Specifications for Structural Steel for Bridges and for Structural Steel for Buildings, was unanimously approved at the annual meeting and the specifications were subsequently adopted by letter ballot of the Society on September 1, 1934. The specifications appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 1, 9 and 16, respectively.

The tentative revisions of the Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement and for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934. The specifications in their revised form appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 23 and 26, respectively.

The withdrawal of the Standard Specifications for Structural Steel for Bridges, for Structural Steel for Buildings, and of the Tentative Specifications for Electric Cast-Steel Stud-Link Anchor Chain was approved.

Recommendations to Committee E-10 on Standards.—Subsequent to the annual meeting Committee A-1 on Steel presented to the Society through Committee E-10 on Standards the following additional recommendations which were accepted by Committee E-10 on August 22, 1934:

Proposed Tentative Specifications for Alloy-Steel Castings for Valves, Flanges and Fittings for Service at Temperatures from 750 to 1100 F. and Specifications for Seamless Alloy-Steel Pipe for Service at Temperatures from 750 to 1100 F., were accepted and appear on pages **609** and **617**, respectively.

Additional revisions of the Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service were accepted. The specifications in their revised form appear on page **637**.

Additional tentative revisions of the Standard Specifications for Structural Steel for Ships, for Welded and Seamless Steel Pipe, for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service, for Alloy-Steel Bolting Materials for High-Temperature Service, and for Forged or Rolled Steel Pipe Flanges for High-Temperature Service were accepted. These revisions supplement the tentative revisions of these specifications which were accepted at the annual meeting. All of the tentative revisions appear on pages **1254**, **1255**, **1256** and **1257**, respectively.

APPENDIX

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR STEEL

In this Appendix are given proposed revisions in certain standard and tentative specifications covering steel and steel products. In connection with each title is given the reference to the publication in which the specifications appear in their present form.

Proposed Tentative Revisions of Standards

Standard Specifications for Open-Hearth Carbon-Steel Rails (A 1 – 30):[1]

Section 3.—Change the table of chemical requirements, appearing in this section, to read as follows by the addition of the italicized figures and the omission of those in brackets:

Elements Considered	Weight, lb. per yd.				
	50–69	70–84	85–100	101–120	121–140
Carbon, per cent	0.50–0.63	0.53–0.70	[0.62] *0.64*–0.77	0.67–[0.83] *0.80*	[0.72–0.89] *0.69–0.82*
Manganese, per cent	0.60–0.90	0.60–0.90	0.60–0.90	[0.50–0.90] *0.70–1.00*	[0.50–0.90] *0.70–1.00*
Phosphorus, max., per cent	0.04	0.04	0.04	0.04	0.04
Silicon, min., per cent	0.15] *0.10–0.23*	[0.15] *0.10–0.23*	[0.15] *0.10–0.23*	[0.15] *0.10–0.23*	[0.15] *0.10–0.23*

Section 12.—Change this section to read as follows by the addition of the italicized words and the omission of the word in brackets:

> 12. The section of the rails shall conform as accurately as possible to the templates *or drawings* furnished by the purchaser. A variation of $\frac{1}{64}$ in. less and $\frac{1}{32}$ in. greater than the specified height will be permitted. A variation of $\frac{1}{16}$ in. in the [length] *width* of either flange will be permitted, but the variation in total width of base must not exceed $\frac{1}{16}$ in. No variation will be allowed in dimensions affecting the fit of the joint bars, except that the fishing template approved by the purchaser may stand out not to exceed $\frac{1}{16}$ in. laterally.

Section 18.—Add to the first sentence of Paragraph (*b*) a reference to the A.R.E.A. type rails, thus making the opening phrase read: "Rails of A.R.A. or A.R.E.A. type of sections."

Add the following as a new Paragraph (*c*):

> (*c*) Rails that are not hot stamped.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 97.

Section 19.—Change this section from its present form to read as follows:

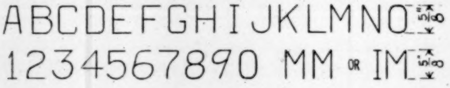
(*a*) The data and order of arrangement of the branding shall be as shown in the following typical branding, the design of letters and numerals to be optional with the manufacturer:

11025	R.E.	O.H.	DOE	1930	IIIIII
(Weight and Section Number)	(Type)	(Kind of Steel)	(Manufacturer and Mill)	(Year Rolled)	(Month Rolled)

(*b*) The heat number and the ingot number as rolled shall be stamped in the web of each rail where it will not be covered by the joint bars. The data used in stamping and arrangement thereof shall be as shown in the following typical stamping:

Example 1:	63345 (Heat Number)	E (Rail Letter)	17 (Ingot No.)
Example 2:	49021	A	5

(*c*) The top rails shall normally be lettered "A," and succeeding ones "B," "C," "D," "E," etc., consecutively, but in case top discard is greater than normal, the rail lettering shall conform to the amount of discard, the top rail becoming "B," or other succeeding letter to suit the condition. Design and size of letters and numerals to be used in stamping shall be as here shown:



(*d*) Only the "A," "B" and "C" rails are required to be lettered when the normal weight per yard is less than 70 lb.

Section 20 (*e*).—Change from its present form: namely,

(*e*) All rails of heats the carbon content of which exceeds the mean carbon percentage of the specific range shall have both ends painted blue.

Individual rails shall be painted only one color, according to the order of precedence listed above.

to read as follows:

(*e*) All rails of a heat whose carbon content is in the upper five points of the carbon percentage of the specified range shall have both ends painted blue.

Individual rails shall be painted only one color, according to the order of precedence listed above.

Section 23 (*c*).—Change to read as follows by the addition of the italicized words:

(*c*) Rails accepted will be paid for according to actual weights, *subject to the limitations of Section 13.*

Standard Specifications for Boiler Rivet Steel and Rivets (A 31 – 24)[1] *and for Structural Rivet Steel (A 141 – 33):*[2]

Section 2.—In the table of chemical requirements change the present requirement for sulfur from "not over 0.045 per cent" to read "not over 0.05 per cent."

Standard Specifications for Structural Steel for Ships (A 131 – 33):[3]

Section 2.—In the table of chemical requirements change the present sulfur requirement for rivet steel from "not over 0.045 per cent" to read "not over 0.05 per cent."

Section 5.—Change this section by the addition of the following clause as a new Paragraph (*b*), relettering the present Paragraph (*b*) as Paragraph (*c*):

> (*b*) Flat rolled steel 3/16 in. and under in thickness, shapes less than 1 sq. in. in cross-section, and bars, other than flats, less than ½ in. in thickness or diameter, shall not be subjected to tension tests.

Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 33)[4] *and for Rail-Steel Concrete Reinforcement Bars (A 16 – 33):*[5]

Permissible Variations in Weight.—Change Section 13 of Specifications A 15 and Section 9 of Specifications A 16 to read as follows by the addition of the italicized words and figures:

> The weight of any lot of bars shall not vary more than 3½ per cent over and under the theoretical weight for bars ⅜ in. and over in diameter; nor more than 5 per cent over and under for bars under ⅜ in. in diameter. *The weight of any individual bar shall not vary more than 6 per cent under the theoretical weight for bars ⅜ in. and over in diameter; nor more than 10 per cent under the theoretical weight for bars under ⅜ in. in diameter.* The theoretical weight of deformed bars shall be the theoretical weight of plain round or square bars of the same nominal size. The term "lot" used in this paragraph means all the bars of the same nominal weight per linear foot in a carload.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 53.

[2] *Ibid.*, p. 27.

[3] *Ibid.*, p. 36.

[4] *Ibid.*, p. 79.

[5] *Ibid.*, p. 84.

Standard Specifications for Carbon-Steel Car and Tender Axles (A 21 – 27):[1]

Section 1.—Change this section to read as follows by the addition of the italicized words and the omission of the word in brackets:

1. These specifications cover tapered axles up to and including those $6\frac{1}{2}$ in. in nominal diameter at the center. Axles over $6\frac{1}{2}$ in. in ***nominal*** diameter at the center ***which*** shall be annealed, [and] shall be in accordance with the Tentative Specifications for Carbon-Steel Forgings for Locomotives (A.S.T.M. Designation: A 20 – 31 T) of the American Society for Testing Materials.

Note.—Add the following Note to Section 1:

NOTE.—Axles with parallel sides, either untreated or annealed as specified, shall be in accordance with the Tentative Specifications for Carbon-Steel Forgings for Locomotives (A.S.T.M. Designation: A 20 – 31 T) of the American Society for Testing Materials.

Section 3.—In the table of chemical requirements change the present range in manganese content from "0.40 to 0.70 per cent" to read "0.40 to 0.90 per cent."

Section 8.—Add the following paragraph as Paragraph (*b*), lettering the present section as Paragraph (*a*):

(*b*) When less than 15 tons of any one design are ordered, the manufacturer shall have the option of making axles from a previously tested melt and furnishing copy of such test, or of making a tension test to the requirements for untreated forgings as specified in the Tentative Specifications for Carbon-Steel Forgings for Locomotives (A.S.T.M. Designation: A 20 – 31 T) of the American Society for Testing Materials.

Section 9.—Change this section from its present form: namely,

9. (*a*) All axles shall be made and finished in a workmanlike manner and shall conform to the sizes and shapes specified by the customer and all journals and wheel seats shall be rough turned. In centering, unless otherwise specified, 60-deg. centers shall be used, with large diameter of counter-sink not less than $\frac{7}{8}$ in. and with clearance drilled $\frac{1}{2}$ in. deep.

(*b*) Unless otherwise specified, axles shall be smooth forged, except the wheel seats and journals, which shall be rough turned.

to read as follows:

9. The axles shall conform to the sizes and shapes specified by the purchaser. Unless otherwise specified, axles shall have smooth-forged finish, except on wheel seats and journals which shall be rough turned. Centering shall be 60-deg. with clearance drilled for points.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 175.

Standard Specifications for Wrought Solid Carbon-Steel Wheels for Electric Railway Service (A 25 – 24):[1]

Section 3.—Separate composition for acid steel is being eliminated and the same chemistry used for both acid and basic steel. It is accordingly recommended that the table of chemical requirements appearing in this section be changed from its present form: namely,

	ACID	BASIC
Carbon, per cent	0.60 – 0.80	0.65 – 0.85
Manganese, per cent	0.55 – 0.80	0.55 – 0.80
Phosphorus, per cent	not over 0.05	not over 0.05
Sulfur, per cent	not over 0.05	not over 0.05
Silicon, per cent	0.15 – 0.35	0.10 – 0.30

to read as follows:

Carbon, per cent	0.65 to 0.85
Manganese, per cent	0.60 to 0.85
Phosphorus, max., per cent	0.05
Sulfur, max., per cent	0.05
Silicon, min., per cent	0.15

Section 5.—Change this section from its present form: namely,

5. An analysis may be made by the purchaser from a wheel representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3. A sample may be taken from any one point in the plate; or two samples may be taken, in which case they shall be on radii at right angles to each other. Samples shall not be taken in such a way as to impair the usefulness of the wheel. Drillings for analysis shall be taken by boring entirely through the sample parallel to the axis of the wheel; they shall be clean and free from scale, oil and other foreign substances. All drillings from any one wheel shall be thoroughly mixed together.

to read as follows:

5. An analysis may be made by the purchaser from a wheel block or from a finished wheel selected by his representative from each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3. Samples from wheel blocks shall be drilled from the end of the block at any point midway between the center and outside. The finished wheels may be sampled by taking drillings direct from the plate, or from the slug hot-punched or cored out of the plate; taken so that it does not impair the usefulness of the wheel. Samples shall be taken by drilling entirely through the plate or slug. Drillings from any one block or wheel shall be thoroughly mixed together and they shall be clean and free from scale, oil and other foreign substances.

Section 7.—The present permissible variations are intended for wheels operating on T-rails. It is now proposed to include variations for wheels operating on grooved rails which will be one-half of the existing tolerances. It is accordingly recommended that Paragraphs (*a*), (*b*), (*c*), and (*j*) be changed to read as follows by the addition of the italicized words and figures:

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 211.

(*a*) Height of Flange.—The height of flange shall not vary from that specified by more than ± $\frac{1}{16}$ in. *for wheels operating on T-rails, nor more than ± $\frac{1}{32}$ in. for wheels operating on grooved rails.*

(*b*) Thickness of Flange.—The thickness of flange shall not vary from that specified by more than ± $\frac{1}{16}$ in. *for wheels operating on T-rails, nor more than ± $\frac{1}{32}$ in. for wheels operating on grooved rails.*

(*c*) Radius of Throat.—The radius of throat shall not vary from that specified by more than ± $\frac{1}{16}$ in. *for wheels operating on T-rails, nor more than ± $\frac{1}{32}$ in. for wheels operating on grooved rails.*

(*j*) Limit-of-Wear Groove.—When a limit-of-wear groove is specified, its location shall not vary from that specified by more than ± $\frac{1}{16}$ in. *for wheels operating on T-rails, nor more than ± $\frac{1}{32}$ in. for wheels operating on grooved rails.*

It is the practice to machine the tread of all wheels for electric service. Accordingly, it is recommended that Paragraphs (*g*) on Rotundity and (*h*) on Block Marks on Tread which read as follows be deleted from this section:

(*g*) *Rotundity.*—The tread shall be gaged with a ring gage, and the opening between the tread and this gage at any point shall not exceed $\frac{1}{16}$ in.

(*h*) *Block Marks on Tread.*—Block marks shall not exceed $\frac{1}{64}$ in. in height.

Table I.—Change Table I in accordance with the modifications being made in Section 7 (*a*), (*b*), (*c*), (*g*), (*h*), and (*j*).

Standard Specifications for Welded and Seamless Steel Pipe (*A 53 – 33*):[1]

Section 1.—Add the following Note to this section:

NOTE. *Galvanizing.*—Galvanized pipe, not subject to coiling, bending or flanging, may be purchased under these specifications. When physical tests are made on galvanized samples, any flaking or cracking of the zinc coating shall not be considered cause for rejection. Galvanizing requirements shall be in accordance with the Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A.S.T.M. Designation: A 120 – 34 T) of the American Society for Testing Materials.[2]

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 247.

[2] See p. 604.—ED.

Standard Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 33):[1]

Explanatory Note.—Change Table I appearing in the Explanatory Note at the end of these specifications, from its present form: namely,

TABLE I.—ADJUSTED SERVICE PRESSURES FOR POWER PIPING AT TEMPERATURES BELOW AND ABOVE 750 F.

Steam Service Pressure Rating at 750 F., lb. per sq. in.	100	300	400	600	900	1500
SERVICE TEMPERATURE, DEG. FAHR.	ADJUSTED SERVICE PRESSURES, LB. PER SQ. IN.					
500	150	370	500	720	1080	1800
550	120	360	480	720	1080	1800
600	115	350	460	700	1040	1740
650	110	330	440	670	1000	1660
700	105	315	420	630	950	1580
750	100	300	400	600	900	1500
800	85	250	325	500	750	1250
850	70	200	270	400	600	1000

to read as follows:

TABLE I.—MAXIMUM SERVICE PRESSURES FOR POWER PIPING AT TEMPERATURES BELOW AND ABOVE 750 F.

Primary Service Pressure Rating at 750 F., lb. per sq. in.	100	300	400	600	900	1500
SERVICE TEMPERATURE, DEG. FAHR.	MAXIMUM SERVICE PRESSURES, LB. PER SQ. IN.					
100	230	500	670	1000	1500	2500
150	220	480	640	960	1440	2400
200	210	465	620	930	1395	2325
250	200	450	600	900	1350	2250
300	190	435	580	870	1305	2175
350	180	420	560	840	1260	2100
400	170	405	540	810	1215	2025
450	160	390	520	780	1170	1950
500	150	375	500	750	1125	1875
550	140	360	480	720	1080	1800
600	130	345	460	690	1035	1725
650	120	330	440	660	990	1650
700	110	315	420	630	950	1575
750	100	300	400	600	900	1500
800	85	250	335	500	750	1250
850	70	200	270	400	600	1000

Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 33):[2]

Section 16.—Change this section to read as follows by the addition of the italicized words, the chemical requirements remaining the same:

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 259.

[2] *Ibid.*, p. 253.

16. Bolts and studs shall be equipped with semi-finished nuts of American Standard heavy dimensions, chamfered and trimmed. *Nuts shall be made by the cold-punched or hot-forged, cold-trimmed process; nuts cut from drawn or rolled bar stock shall not be permitted.* If washers are used under nuts, they shall be of forged or rolled steel. All nuts and washers shall be free from injurious defects and shall have a workmanlike finish. Nuts shall conform to the chemical requirements for phosphorus and sulfur as follows:

Section 17.—Change this section to read as follows by the addition of the italicized words:

17. American National Standard coarse screw threads shall be used, except that no stud *or bolt* shall have less than eight threads per inch.

Explanatory Note.—Make the same change in Table I, appearing in the Explanatory Note at the end of these specifications, as is recommended above in the Explanatory Note of Specifications A 95 – 33.

Standard Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A 105 – 33):[1]

Class A Flanges.—Delete from these specifications all requirements for Class A flanges. This deletion will require adjustment of the following sections: 1 (*b*), 5 (*a*) and (*b*), 6 (*a*) and (*b*), 9 (*a*) and Explanatory Note 2. In order to avoid the inconsistency of having Classes *B* and *C* referred to with no Class *A*, redesignate the two remaining classes of flanges as Classes I and II.

Explanatory Note.—Make the same change in Table I, appearing in the Explanatory Note at the end of these specifications, as is recommended above in the Explanatory Note of Specifications A 95 – 33.

PROPOSED REVISIONS OF TENTATIVE STANDARDS

Tentative Specifications for Forge-Welded Steel Pipe (A 136–32 T):[2]

Section 8 (b).—Change the time specified for maintaining the test pressure in the hydrostatic test from the present requirement of not less than "5 sec." to read "30 sec."

Tentative Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139 – 32 T):[2]

Section 14.—Change the Note following this section to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

NOTE.—The weld shall show thorough penetration and good fusion with no appreciable under-cutting and shall be at least flush with the surface of the pipe. The weld metal shall not project more than [30] *50* per cent *of the wall*

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 264.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 576, 564 (1932); also 1933 Book of A.S.T.M. Tentative Standards, pp. 97, 82.

thickness for pipe [⅜] $\frac{3}{16}$ in. or less in thickness; ***not over 30 per cent for pipe over*** $\frac{3}{16}$ ***in. up to and including*** ⅜ ***in. in thickness;*** and ***not over*** 25 per cent for [pipe over that thickness] ***pipe over*** ⅜ ***in. in thickness.***

Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 33 T):[1]

Section 5 (a).—In the table of tensile properties change the minimum elongation in 2-in. for Grade A seamless material from the present requirement of "30 per cent" to read "35 per cent"; also in the footnote to the table change the minimum elongation for the transverse tests of Grade A seamless material from the present requirement of "25 per cent" to read "30 per cent."

Explanatory Note 1.—Change Table II appearing in the Explanatory Note at the end of these specifications from its present form: namely,

TABLE II.—ADJUSTED SERVICE PRESSURES[a] FOR POWER PIPING AT TEMPERATURES BELOW AND ABOVE 750 F.

Steam Service Pressure Rating at 750 F., lb. per sq. in.	250	300	400	600	900	1500
SERVICE TEMPERATURE, DEG. FAHR.	ADJUSTED SERVICE PRESSURES, LB. PER SQ. IN.					
500	310	370	500	720	1080	1800
550	300	360	480	720	1080	1800
600	290	350	460	700	1040	1740
650	280	330	440	670	1000	1660
700	260	315	420	630	950	1580
750	250	300	400	600	900	1500
800	200	250	325	500	750	1250
850	165	200	270	400	600	1000

[a] These ratings apply to Table I, Dimensions and Weights of Lap-Welded and Grade-A-Seamless Steel Pipe for High-Temperature Service.

to read as follows:

TABLE II.—MAXIMUM SERVICE PRESSURES[a] FOR POWER PIPING AT TEMPERATURES BELOW AND ABOVE 750 F.

Steam Service Pressure Rating at 750 F., lb. per sq. in.	250	300	400	600	900	1500
SERVICE TEMPERATURE, DEG. FAHR.	MAXIMUM SERVICE PRESSURES, LB. PER SQ. IN.					
700	260	315	420	630	950	1575
750	250	300	400	600	900	1500
800	200	250	335	500	750	1250
850	165	200	270	400	600	1000

[a] These ratings apply to Table I, Dimensions and Weights of Lap-Welded and Grade-A-Seamless Steel Pipe for High-Temperature Service.

---

[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 33, Part I, p. 572 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 114.

DISCUSSION

Mr. H. J. Gilkey[1] (*by letter*).—Referring to the Society's Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 33) and for Rail-Steel Concrete Reinforcement Bars (A 16 – 33), revisions of which are being recommended this year by Committee A-1, why should it be necessary to specify either tolerances of weight or cross-sectional area for reinforcement bars? The purchaser of steel reinforcement is interested in neither. He needs a certain total strength in a given member and the designer specifies the number of bars to supply this strength on the basis of design stresses and nominal areas. When the steel is delivered, the only question of practical concern to the purchaser should be, "Will a bar of this steel supply the resistance that my designer has allocated to it and still meet the ductility requirement as specified in terms of percentage elongation and the cold bend test?"

An employer of men is interested in what a man can do, not in how large or how heavy he may be. Similarly the purchaser of steel should test his shipment on the basis of the performance of representative bars, selected as any other sample would be selected. The design is on the basis of bars of nominal areas. Acceptance tests and payments should be on the same basis. It is of no practical concern to the purchaser if a bar 10 per cent under-size will do all that is expected of a full-size bar. Nor has he any valid reason for demanding a reduction in price because of decreased tonnage. He has received the strength that he requested and the dictates of adequacy have been met. Similarly, there is no element of fairness in passing along to the purchaser the extra cost for tonnage overrun. Should a man be required to pay his tailor extra for cloth because he made the suit too large?

The present procedure of specifying tolerances for weight (or area) is inherently unsound and is objectionable for the following reasons:

1. It clutters the specifications with an additional clause to be administered but one which is irrelevant and which has no bearing upon the adequacy of the material and which should be permitted to have no bearing upon the price to be paid for it.

---

[1] Head, Department of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa.

2. It implies that it is quantity or tonnage of steel in which a purchaser is interested, which is not the case. A structural member, as designed, requires so many linear feet of strength and it is this that is being purchased.

3. Sharp practices are encouraged and no legitimate incentive for close control is offered. If payment is on the basis of weighed rather than nominal tonnage, a premium is placed upon keeping the product as near the upper range of the weight (or area) tolerance as possible, increasing the overrun, for which the producer receives added money without supplying anything of added value to the purchaser. If payment is on nominal tonnages with acceptance tests on actual areas, the incentive is then to skimp the bars and keep them near the lower limit of tolerance, in which case the producer receives full pay for bars deficient in total strength. Unless there is to be intentional shading, there is no direct incentive for a manufacturer to attempt to maintain a close control over his product.

With tonnages, tests and payments all on the basis of nominal areas, there are manifold advantages that promote simplicity and fairness and which place a premium upon careful control of product for reputable purposes.

1. Purchase, delivery and payments are all placed on the same basis as the design where the magnitude of the need was determined initially.

2. The purchaser is buying so much strength; the manufacturer who has good control over his product may be able to supply the necessary strength by supplying a bar of somewhat less diameter and still meet the ductility requirements. In attempting to do this he assumes the risk of rejections because of:

(*a*) Apparent weakness of material due to actual lack of section, or

(*b*) Failure to meet ductility requirements from an effort to get high strength (and reduced area) by raising the carbon content.

The purchaser is or can be safeguarded fully by the opposing limits set for strength and ductility. It should be to the interest of the manufacturer to discharge his contract with the least possible tonnage of steel and he should be entitled to any saving in tonnage that he can effect. On the other hand, a manufacturer who is fearful of his product can play safe by rolling his bars over-size. He himself assumes the added tonnage as insurance against a possible rejection of his product. It is of no concern to the purchaser that one bar is over-size and the other under-size if they are of equal strength, have the specified ductility, and cost the same amount of money.

3. Reputable manufacturers cannot be penalized but will rather stand a chance of being rewarded. It is just as easy to regulate a fair price per ton based on nominal areas as on actual weights or areas or on any other basis. In fact, it is easier because of the added simplicity.

4. Acceptance tests would be simpler and without bickerings over weights or true cross-sectional areas. Such tests would not, however, be any less certain or convincing. The same number of samples could be selected and the same methods of sampling could be employed. The added simplicity is especially important in the case of deformed bars.

5. The limits set for strength and ductility would be the sole basis for the tolerance and this could be made anything desired.

Viewed from whatever angle one may select, the writer can see no justification for any mention of weight or area in a specification for steel reinforcement. On the other hand, it provides unsavory possibilities which can be of but transient benefit to the unscrupulous and of no benefit to other producers. Instead of quibbling about what tolerances should be set, is it not more timely to restudy the question of tolerances in weight with a view to their elimination?

EFFECT OF SULFUR ON FORGING STEEL

REPORT OF THE JOINT COMMITTEE ON INVESTIGATION OF THE EFFECT OF PHOSPHORUS AND SULFUR IN STEEL

INTRODUCTION

The Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel was formed in 1919 by the joint action of the American Society for Testing Materials, the National Bureau of Standards and the United States Railroad Administration. The full personnel of the committee consists of representatives from the following organizations:

American Society for Testing Materials,
American Railway Association, Mechanical Division,
American Foundrymen's Association,
Association of American Steel Mfgrs. Technical Committees,
American Petroleum Institute,
National Bureau of Standards,
Society of Automotive Engineers,
Society of Naval Architects and Marine Engineers,
United States Navy Department,
United States War Department,
Engineering Division, National Research Council.

The general program laid down by the committee can be briefly summarized as follows:

Series A, steels of variable sulfur content, the sulfur being "residual," that is, present throughout the melting operations.
Series B, steels of variable sulfur content, the sulfur being added late in the melting operation.
Series C, steels of variable "residual" phosphorus.
Series D, steels of variable "added" phosphorus.

Each series consisted of six groups of steels, as follows:

GROUP	MATERIAL	CARBON, PER CENT	MANGANESE, PER CENT
I	Rivet steel, tubes, etc	0.06 – 0.12	0.35 – 0.40
II	Plates and structural shapes	0.16 – 0.22	0.35 – 0.40
III	Forging steel	0.45 – 0.55	0.50 – 0.60
IV	Wheel, tire and rail steel	0.65 – 0.75	0.60 – 0.70
V	Spring steel	0.95 – 1.05	0.35 – 0.45
VI	Castings	....	....

A résumé of the work of the joint committee was given in its 1928 progress report.[1] Respecting Series A, the effect of residual sulfur on group I steel has been finally reported upon[2]; also the effect of residual sulfur on group II steel.[3] The effect of residual sulfur on group III steel is the subject of the present report. The program as applied to series A, groups IV, V and VI steels, has not been carried out.[4]

Respecting series B, the effect of added sulfur on steels of groups II, III and IV was reported in 1923.[5] No further studies in this series are contemplated.

Respecting series C, precedence was given to a study of effect of residual phosphorus on cast steels (group VI). As described in 1928, eight heats of steel of varying residual phosphorus were manufactured.[1] It was later found upon testing that this material was unsatisfactory as a basis for study of effect of phosphorus on this class of steel. It was planned to procure a new lot of steel for the purpose, but industrial conditions since that time have made it impossible to proceed with the program.

In series D, the effect of added phosphorus upon group I steel is being reported this year.[6]

The present report deals with simple carbon forging steels containing residual sulfur in progressively increasing amounts (series A, group III). These steels were of the quality intended for ordinary usage and not for automotive or ordnance use. The primary purpose of the work was the determination of the effect of sulfur on those properties of the steels at room temperature which may have a bearing on the service behavior. It was recognized, of course, that the effect of sulfur on steel while at high temperature, approximately that at which forging operation is carried out, may be detrimental to the working of the steel. As is well known, the seriousness of this effect depends on both the amount of sulfur present and the form in which it occurs in the steel. Observations on the behavior of the various heats during rolling and forging were made, as summarized in the succeeding section. The assumption has been made by the committee that if any individual material could be rolled or forged without difficulty on an industrial scale of operation, the possible "hot shortness" effect of sulfur was of no practical commercial significance with respect to that material. Detailed study of the various properties at high temperature was not made, since in any case the significance of the results of such tests could be decided only by mechanically working the material on a large scale in commercial operation.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 95 (1928).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 94 (1922); Vol. 24, Part I, pp. 96 and 108 (1924); Vol. 26, Part I, p. 114 (1926).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 185 (1924); Vol. 27, Part I, p. 135 (1927).

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 131 (1927).

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 105 (1923).

[6] Effect of Added Phosphorus on Low-Carbon Steel—Report of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel, see p. 113.

MATERIALS

The materials represented eight heats of steel made at the South Side Works of the Jones & Laughlin Steel Corp. in July to August, 1927, in accordance with the arrangements made with the Association of American Steel Manufacturers. This lot of steel replaced an earlier lot, prepared in 1923, which upon testing was considered by the committee to be unsatisfactory as a basis of study of the effect of the variable, sulfur. The manufacture of the second lot was witnessed by the Subcommittee on Manufacture.

TABLE I.—CHEMICAL COMPOSITION OF STEELS, DETERMINED BY MILL ANALYSIS.

Heat Letter	Desired Composition, per cent				Accepted Composition, per cent									
	Sulfur	Carbon	Manganese	Phosphorus	Sulfur		Carbon		Manganese		Phosphorus		Silicon	
					Ladle	Billet	Ladle	Billet	Ladle	Billet	Ladle	Billet	Ladle	Billet
A	0.030	0.45 - 0.55	0.56 - 0.60	0.02 - 0.03	0.031	0.031	0.54	0.58	0.71	0.75	0.012	0.013	0.21	.....
B	0.040	0.45 - 0.55	0.56 - 0.60	0.02 - 0.03	0.035	0.038	0.51	0.51	0.55	0.55	0.012	0.012	0.21	.....
C	0.050	0.45 - 0.55	0.56 - 0.60	0.02 - 0.03	0.047	0.052	0.51	0.57	0.64	0.66	0.012	0.013	0.25	.....
D	0.060	0.45 - 0.55	0.56 - 0.60	0.02 - 0.03	0.052	0.061	0.49	0.49	0.65	0.65	0.010	0.012	0.24	.....
E	0.070	0.45 - 0.55	0.56 - 0.60	0.02 - 0.03	0.069	0.069	0.54	0.56	0.60	0.62	0.012	0.012	0.29	.....
F	0.080	0.45 - 0.55	0.56 - 0.60	0.02 - 0.03	0.070	0.070	0.49	0.49	0.76	0.75	0.006	0.018	0.25	.....
G	0.090	0.45 - 0.55	0.56 - 0.60	0.02 - 0.03	0.089	0.097	0.45	0.45	0.65	0.67	0.017	0.017	0.23	.....
H	0.10	0.45 - 0.55	0.56 - 0.60	0.02 - 0.03	0.109	0.116	0.53	0.54	0.48	0.47	0.010	0.012	0.31	.....

The steel was made in 50-ton lots, by the usual basic open-hearth practice, the sulfur being introduced by the use of selected scrap. In addition to the usual additions in the furnace of both ferrosilicon and ferromanganese, each heat was treated in the ladle with ferrosilicon and carbon (coal) and three received additional ferromanganese. The metal was poured in Gathmann hot-top ingot molds either 24 by 26 in. or 18 by 18 in. in cross-section. The first one or two ingots of each heat were poured in regular molds and not included in the committee's material. The compositions of the eight heats as determined by the mill analysis are summarized in Table I.

The rolling of heats F, G and H containing the higher sulfurs was observed. The 18 by 18-in. ingots were given nine passes in the first series of rolls and seven passes in the second series, the final cross-section of the billets being 4 by 4 in. The ingots of heat F rolled rather well, showing few if any cracks in the finished billets.

In rolling heat H, the "hot tops" of two of the ingots broke off and a number of cracks and checks were noticed in the finished billets. The 9 by 9-in. billets rolled from the large ingots of heat G (which were given from 26 to 30 passes in the rolls) showed several cracks and the "hot tops" in particular showed bad longitudinal cracks.

Billets of two sizes, 9 by 9 in. and 4 by 4 in. in cross-section, were rolled from each ingot. The smaller billets were rolled into the form of rounds of 1-in. and hammer-forged into rounds of 2-in. diameter. This was done in the Jones & Laughlin mill. The 9 by 9-in. billets were forged into rounds of 8-in. diameter, the forging being done by the Carnegie Steel Co. The total amount of material received by the committee comprised 208 1-in. rounds, 208 2-in. rounds and 160 8-in. rounds. The 8-in. rounds were 18 in. in length; the others, 4 ft. 6 in. in length.

Heat Treatment.—The material was heat treated at the Washington Naval Gun Factory according to the schedule furnished by the Bureau of Standards. The large-scale equipment available at the Naval Gun Factory assured a heat treatment which could not be criticized as being small-scale or experimental.

All of the steel was first annealed, the annealing being carried out as follows: All specimens were heated in the furnace from room temperature to 1500 F. (815 C.), held at this temperature from 1 to 4 hours according to the size (1-in. round, 1 hour; 2-in. round, 1½ hours; 8-in. round, 4 hours) and then cooled in the furnace.

One-half of the annealed rounds of each size were then quenched and tempered, as follows:

Size	Heated to	Time at 1500 F. (815 C.), hr.	Time of Quenching in Water, min.	Drawing Temperature	Time at Drawing Temperature, hr.[a]
1-in.	1500 F. (815 C.)	1	½	1175 F. (635 C.)	1
2-in.	1500 F. (815 C.)	1½	1¼	1175 F. (635 C.)	1½
8-in.	1500 F. (815 C.)	4	6	1175 F. (635 C.)	4

[a] Specimens were cooled in the furnace after holding for the time shown.

The Brinell hardness was determined on each of the quenched-and-tempered specimens, this impression being made on a spot flattened by grinding the cylindrical surface near both ends of the smaller rounds and near the middle of the length for the 8-in. rounds. The maximum deviation in Brinell hardness from the average was within 15 points, and the results were accepted as indicating uniform heat treatment. Thirty-two 1-in. rounds (4 from each heat), thirty-two 2-in. rounds (4 from each heat) and twenty-four 8-in. rounds (3 from each heat) were sent to the U. S. Naval Engineering Experiment

TABLE II.—CHEMICAL COMPOSITION OF 1-IN. ROUNDS; NAVAL EXPERIMENT STATION DATA.

Each value reported is the average of four determinations except as noted.

Heat Letter	Composition, per cent[f]							
	Sulfur		Carbon	Manganese	Phosphorus	Silicon	Chromium	Copper
	Volumetric	Gravimetric						
A	0.024[c]	0.020	0.61	0.74	0.023	0.23	0.046	0.02
B	0.033[c]	0.026	0.55	0.52	0.011	0.25	0.053	0.02
C[a]	0.044[d]	0.047	0.53	0.68	0.012	0.23	less than 0.02	0.02
D[b]	0.052[e]	0.054	0.51	0.61	0.010	0.23	0 .046	0.03
E	0.063[c]	0.062	0.51	0.61	0.011	0.28	less than 0.02	0.02
F	0.071[c]	0.069	0.48	0.77	0.015	0.24	less than 0.02	0.02
G	0.091[c]	0.090	0.43	0.66	0.0125	0.23	less than 0.02	0.02
H	0.103[c]	0.107	0.60	0.43	0.014	0.28	0.051	0.03

[a] Average based on three determinations except for volumetric sulfur.
[b] Average based on five determinations except for volumetric sulfur.
[c] Average of eight determinations.
[d] Average of six determinations.
[e] Average of ten determinations.
[f] Nickel, nil throughout.

NOTE.—The volumetric sulfur values were used in plotting the results in the graphs (Figs. 3 and 4) in accordance with N.E.S. tabulated data.

TABLE III.—CHEMICAL COMPOSITION OF 2-IN. ROUNDS; NAVAL EXPERIMENT STATION DATA.

Each value reported is the average of four determinations except as noted.

Heat Letter	Sample[a]	Composition, per cent[c]						
		Sulfur		Carbon[b]	Manganese	Phosphorus	Silicon	Copper
		Volumetric	Gravimetric					
A	C	0.022[b]	0.018	0.53	0.69	0.023	0.21	0.02
	M	0.028[b]	0.020	0.59	0.73	0.023	0.20	0.03
B	C	0.033	0.028	0.54	0.53	0.013	0.21	0.03
	M	0.036[b]	0.031	0.55	0.54	0.015	0.23	0.01
C	C	0.047[b]	0.035	0.50	0.53	0.012	0.20	0.02
	M	0.054[b]	0.049	0.54	0.64	0.010	0.25	0.03
D	C	0.052[b]	0.052	0.47	0.62	0.012	0.22	0.02
	M	0.063[b]	0.056	0.49	0.65	0.011	0.24	0.02
E	C	0.061[b]	0.056	0.51	0.56	0.010	0.27	0.02
	M	0.072[b]	0.074	0.56	0.59	0.011	0.30	0.01
F	C	0.062[b]	0.060	0.49	0.66	0.014	0.23	0.02
	M	0.073[b]	0.072	0.49	0.74	0.016	0.25	0.02
G	C	0.082[b]	0.077	0.41	0.62	0.012	0.21	0.03
	M	0.087[b]	0.092	0.44	0.63	0.013	0.24	0.02
H	C	0.085[b]	0.087	0.47	0.43	0.012	0.29	0.02
	M	0.104[b]	0.103	0.51	0.44	0.013	0.31	0.02

[a] Sample C, from center of cross-section of bar;
Sample M, midway between center and circumference of cross-section of bar.
[b] Average of eight determinations.
[c] Nickel, nil throughout; Chromium, less than 0.02 per cent in all cases.

NOTE.—The volumetric sulfur values for each sample, C and M, were used in plotting the data in the graphs (Figs. 5 and 6) in accordance with N.E.S. tabulated data.

TABLE IV.—CHEMICAL COMPOSITION OF 8-IN. ROUNDS; NAVAL EXPERIMENT STATION DATA.

Heat Letter	Position of Sample[a]	Composition, per cent[b]							
		Sulfur		Carbon	Manganese	Phosphorus	Silicon	Chromium	Copper
		Volumetric	Gravimetric						
A	No. 1	0.027	0.020	0.58	0.77	0.025	0.22	0.033	0.02
	No. 2	0.026	0.021	0.54	0.77	0.024	0.21	0.033	0.02
	No. 3	0.022	0.017	0.49	0.76	0.024	0.21	0.033	0.02
	No. 4	0.029	0.023	0.58	0.76	0.024	0.22	0.033	0.02
	Average	0.026	0.020	0.55	0.77	0.024	0.22	0.033	0.02
B	No. 1	0.033	0.026	0.54	0.53	0.015	0.24	0.053	0.01
	No. 2	0.030	0.029	0.48	0.53	0.015	0.24	0.053	0.01
	No. 3	0.028	0.024	0.44	0.53	0.015	0.24	0.053	0.01
	No. 4	0.031	0.027	0.50	0.53	0.015	0.24	0.053	0.01
	Average	0.031	0.027	0.49	0.53	0.015	0.24	0.053	0.01
C	No. 1	0.051	0.049	0.55	0.54	0.014	0.21	0.047	0.02
	No. 2	0.044	0.042	0.51	0.54	0.014	0.24	0.047	0.02
	No. 3	0.038	0.034	0.48	0.55	0.014	0.21	0.047	0.02
	No. 4	0.050	0.044	0.51	0.54	0.015	0.23	0.047	0.02
	Average	0.046	0.042	0.51	0.54	0.014	0.22	0.047	0.02
D	No. 1	0.055	0.058	0.46	0.67	0.012	0.22	0.046	0.01
	No. 2	0.059	0.059	0.48	0.66	0.012	0.23	0.045	0.01
	No. 3	0.049	0.050	0.46	0.66	0.012	0.22	0.046	0.01
	No. 4	0.057	0.058	0.48	0.67	0.012	0.23	0.045	0.01
	Average	0.055	0.056	0.47	0.67	0.012	0.23	0.046	0.01
F	No. 1	0.066	0.070	0.48	0.71	0.015	0.22	0.067	0.02
	No. 2	0.063	0.068	0.46	0.72	0.015	0.21	0.062	0.02
	No. 3	0.057	0.060	0.41	0.71	0.015	0.22	0.067	0.02
	No. 4	0.066	0.066	0.46	0.72	0.015	0.21	0.062	0.02
	Average	0.063	0.066	0.45	0.72	0.015	0.22	0.065	0.02
E	No. 1	0.067	0.067	0.54	0.61	0.012	0.25	0.010	0.02
	No. 2	0.065	0.067	0.54	0.61	0.012	0.28	0.013	0.02
	No. 3	0.060	0.062	0.53	0.61	0.012	0.25	0.010	0.02
	No. 4	0.067	0.068	0.55	0.61	0.012	0.28	0.013	0.02
	Average	0.065	0.066	0.54	0.61	0.012	0.27	0.012	0.02
G	No. 1	0.089	0.093	0.43	0.68	0.014	0.20	0.028	0.02
	No. 2	0.093	0.094	0.44	0.68	0.014	0.21	0.025	0.02
	No. 3	0.078	0.078	0.42	0.68	0.014	0.20	0.028	0.02
	No. 4	0.090	0.094	0.45	0.68	0.014	0.20	0.025	0.02
	Average	0.087	0.090	0.43	0.68	0.014	0.20	0.027	0.02
H	No. 1	0.098	0.104	0.51	0.45	0.011	0.27	0.043	0.02
	No. 2	0.087	0.082	0.46	0.45	0.011	0.30	0.044	0.02
	No. 3	0.077	0.065	0.44	0.45	0.011	0.29	0.043	0.02
	No. 4	0.089	0.081	0.46	0.45	0.011	0.27	0.044	0.02
	Average	0.088	0.083	0.47	0.45	0.011	0.28	0.044	0.02

[a] Sample No. 1, at circumference;
Sample No. 2, midway between center and circumference;
Sample No. 3, at center;
Sample No. 4, midway between center and circumference, 180 deg. from No. 2.

[b] Nickel, nil throughout.

NOTE.—The volumetric sulfur values were used on plotting the data in the graphs (Figs. 7 and 8), the average for the four positions being used in accordance with the tabulated N.E.S. data.

TABLE V.—CHEMICAL COMPOSITION OF 8-IN. ROUNDS; WATERTOWN ARSENAL DATA.

Averages have been rounded off.

Heat Letter	Condition	Position of Sample[a]	Composition, per cent[b]							
			Sulfur		Carbon	Manganese	Phosphorus	Silicon	Chromium	Copper
			Volumetric	Gravimetric						
A......	Annealed	No. 1..............	0.030	.....	0.59	0.735	0.029	0.210	.....	.....
		No. 2..............	0.033	.....	0.59	0.735	0.027	0.195	.....	.....
		No. 3..............	0.029	.....	0.59	0.675	0.026	0.205	.....	.....
		No. 4..............	0.034	.....	0.58	0.71	0.027	0.205	.....	.....
		Avg. Nos. 2 and 4....	0.034	.....	0.58	0.72	0.027	0.20	0.025	0.024
	Quenched and Tempered	No. 1..............	0.029	0.030	0.59	0.735	0.027	0.215	.....	.....
		No. 2..............	0.030	0.030	0.57	0.735	0.026	0.210	.....	.....
		No. 3..............	0.029	0.030	0.55	0.675	0.024	0.200	.....	.....
		No. 4..............	0.030	.....	0.575	0.735	0.027	0.200	.....	.....
		Avg. Nos. 2 and 4....	0.030	.....	0.57	0.73	0.027	0.21	.....	.....
B......	Annealed	No. 1..............	0.038	.....	0.555	0.54	0.013	0.220	.....	.....
		No. 2..............	0.040	.....	0.535	0.54	0.014	0.225	.....	.....
		No. 3..............	0.040	.....	0.47	0.53	0.012	0.215	.....	.....
		No. 4..............	0.040	.....	0.52	0.54	0.014	0.230	.....	.....
		Avg. Nos. 2 and 4....	0.040	.....	0.53	0.54	0.014	0.23	0.035	0.016
	Quenched and Tempered	No. 1..............	0.038	0.0385	0.55	0.54	0.013	0.215	.....	.....
		No. 2..............	0.040	0.040	0.54	0.55	0.015	0.215	.....	.....
		No. 3..............	0.039	0.040	0.48	0.53	0.014	0.225	.....	.....
		No. 4..............	0.041	.....	0.545	0.54	0.016	0.230	.....	.....
		Avg. No. 2 and 4....	0.040	.....	0.54	0.55	0.016	0.22	.....	.....
C......	Annealed	No. 1..............	0.052	.....	0.575	0.62	0.011	0.215	.....	.....
		No. 2..............	0.054	.....	0.575	0.645	0.013	0.215	.....	.....
		No. 3..............	0.053	.....	0.540	0.645	0.011	0.215	.....	.....
		No. 4..............	0.054	.....	0.580	0.63	0.012	0.215	.....	.....
		Avg. Nos. 2 and 4....	0.054	.....	0.58	0.64	0.013	0.215	0.09	0.030
	Quenched and Tempered	No. 1..............	0.052	0.053	0.57	0.63	0.012	0.225	.....	.....
		No. 2..............	0.054	0.055	0.58	0.66	0.013	0.225	.....	.....
		No. 3..............	0.053	0.054	0.56	0.66	0.012	0.220	.....	.....
		No. 4..............	0.055	.....	0.58	0.66	0.013	0.230	.....	.....
		Avg. Nos. 2 and 4....	0.055	.....	0.58	0.66	0.013	0.23	.....	.....
D......	Annealed	No. 1..............	0.063	.....	0.49	0.62	0.013	0.230	.....	.....
		No. 2..............	0.066	.....	0.50	0.63	0.014	0.230	.....	.....
		No. 3..............	0.065	.....	0.51	0.63	0.014	0.230	.....	.....
		No. 4..............	0.0655	.....	0.51	0.63	0.014	0.230	.....	.....
		Avg. Nos. 2 and 4....	0.066	.....	0.51	0.63	0.014	0.23	0.045	0.02
	Quenched and Tempered	No. 1..............	0.060	0.062	0.485	0.63	0.012	0.235	.....	.....
		No. 2..............	0.061	0.065	0.495	0.64	0.013	0.235	.....	.....
		No. 3..............	0.0625	0.064	0.51	0.64	0.013	0.235	.....	.....
		No. 4..............	0.060	.....	0.50	0.63	0.013	0.230	.....	.....
		Avg. Nos. 2 and 4....	0.061	.....	0.50	0.64	0.013	0.23	.....	.....

[a] Sample No. 1, at circumference;
Sample No. 2, midway between center and circumference;
Sample No. 3, at center;
Sample No. 4, midway between center and circumference, 180 deg. from No. 2.

[b] Nickel, nil throughout.

NOTE.—In plotting the data in the curves (Figs. 9 and 10) the average of the sulfur contents for the two midway positions (Nos. 2 and 4) was used; also in indicating the range in carbon and manganese (Fig. 1), the averages for these elements in the midway positions were used as the basis of comparison.

TABLE V.—CHEMICAL COMPOSITION OF 8-IN. ROUNDS.—(*Continued*).

Averages have been rounded off.

Heat Letter	Condition	Position of Sample[a]	Composition, per cent[b]							
			Sulfur		Carbon	Manganese	Phosphorus	Silicon	Chromium	Copper
			Volumetric	Gravimetric						
E......	Annealed	No. 1..............	0.071	.....	0.53	0.60	0.012	0.265	....	.....
		No. 2..............	0.073	.....	0.555	0.62	0.013	0.265	....	.....
		No. 3..............	0.072	.....	0.570	0.62	0.012	0.270	....	.....
		No. 4..............	0.072	.....	0.545	0.61	0.013	0.260	....	.....
		Avg. Nos. 2 and 4....	0.072	.....	0.55	0.62	0.013	0.26	0.05	0.02
	Quenched and Tempered	No. 1..............	0.0695	0.073	0.55	0.60	0.013	0.255	....	.....
		No. 2..............	0.0705	0.073	0.54	0.62	0.012	0.255	....	.....
		No. 3..............	0.069	0.073	0.56	0.61	0.012	0.265	....	.....
		No. 4..............	0.0705	.....	0.56	0.61	0.012	0.270	....	.....
		Avg. Nos. 2 and 4....	0.0705	.....	0.55	0.62	0.012	0.265	....	.....
F......	Annealed	No. 1..............	0.072	.....	0.475	0.73	0.017	0.230	....	.....
		No. 2..............	0.073	.....	0.490	0.73	0.0175	0.230	....	.....
		No. 3..............	0.072	.....	0.480	0.74	0.017	0.225	....	.....
		No. 4..............	0.0735	.....	0.490	0.74	0.0175	0.225	....	.....
		Avg. Nos. 2 and 4....	0.073	.....	0.49	0.74	0.0175	0.23	0.055	0.024
	Quenched and Tempered	No. 1..............	0.0705	0.074	0.48	0.73	0.017	0.225	....	.....
		No. 2..............	0.072	0.074	0.485	0.74	0.0175	0.235	....	.....
		No. 3..............	0.070	0.070	0.49	0.74	0.017	0.240	....	.....
		No. 4..............	0.071	.....	0.49	0.74	0.017	0.235	....	.....
		Avg. Nos. 2 and 4....	0.072	.....	0.49	0.74	0.017	0.235	....	.....
G......	Annealed	No. 1..............	0.097	.....	0.44	0.67	0.017	0.200	....	.....
		No. 2..............	0.097	.....	0.44	0.66	0.016	0.200	....	.....
		No. 3..............	0.083	.....	0.40	0.66	0.015	0.205	....	.....
		No. 4..............	0.096	.....	0.43	0.67	0.016	0.200	....	.....
		Avg. Nos. 2 and 4....	0.097	.....	0.44	0.67	0.016	0.20	0.09	0.026
	Quenched and Tempered	No. 1..............	0.097	0.098	0.44	0.66	0.016	0.195	....	.....
		No. 2..............	0.094	0.098	0.45	0.66	0.016	0.200	....	.....
		No. 3..............	0.084	0.087	0.41	0.66	0.015	0.200	....	.....
		No. 4..............	0.096	.....	0.445	0.67	0.016	0.205	....	.....
		Avg. Nos. 2 and 4 ...	0.095	.....	0.45	0.67	0.016	0.20	....	.....
H......	Annealed	No. 1..............	0.119	.....	0.525	0.47	0.016	0.265	....	.....
		No. 2..............	0.124	.....	0.545	0.46	0.017	0.285	....	.....
		No. 3..............	0.110	.....	0.52	0.47	0.016	0.280	....	.....
		No. 4..............	0.124	.....	0.55	0.47	0.017	0.270	....	.....
		Avg. Nos. 2 and 4....	0.124	.....	0.55	0.47	0.017	0.28	0.07	0.020
	Quenched and Tempered	No. 1..............	0.116	0.120	0.51	0.46	0.016	0.260	....	.....
		No. 2..............	0.122	0.128	0.545	0.47	0.017	0.285	....	.....
		No. 3..............	0.116	0.117	0.53	0.46	0.016	0.275	....	.....
		No. 4..............	0.122	.....	0.535	0.46	0.016	0.280	....	.....
		Avg. Nos. 2 and 4....	0.122	.....	0.54	0.47	0.017	0.28	....	.....

[a] Sample No. 1, at circumference;
Sample No. 2, midway between center and circumference;
Sample No. 3, at center;
Sample No. 4, midway between center and circumference, 180 deg. from No. 2.

[b] Nickel, nil throughout.

NOTE.—In plotting the data in the curves (Figs. 9 and 10) the average of the sulfur contents for the two midway positions (Nos. 2 and 4) was used; also in indicating the range in carbon and manganese (Fig. 1), the averages for these elements in the midway positions were used as the basis of comparison.

Station and a similar set to Watertown Arsenal, U. S. War Department, where all the testing work was done. The remainder were stored at the Bureau of Standards.

Chemical Composition.—Much work was done in determining the composition of the forged rounds. The results are summarized in Tables II to V, inclusive. In addition, the variations in carbon and manganese content for the various heats are shown in Fig. 1.

TABLE VI.—KIND AND NUMBER OF TESTS AND LOCATION OF TEST SPECIMENS.

Tests	1-in. Rounds; Naval Experiment Station			2-in. Rounds; Naval Experiment Station				8-in. Rounds; Both Laboratories, Except as Noted		
	Location of Specimen	Number of Tests, One Laboratory		Location of Specimen[a]		Number of Tests, One Laboratory		Location of Specimen[a]	Number of Tests, *Each* Laboratory	
		Annealed	Quenched and Tempered			Annealed	Quenched and Tempered		Annealed	Quenched and Tempered
Tension	Longitudinal	3	3	Longitudinal	C M	3 3	3 3	Longitudinal, M[b] Transverse, tangential, M[b] Transverse, radial	4 4 2	4 4 2
Torsion	Longitudinal	2	2	Longitudinal	C M	2 2	2 2	Longitudinal, M[c]	3	3
Charpy Impact	Longitudinal	3	3	Longitudinal	C M	3 3	3 3	Longitudinal, M[d] Transverse, approximately radial, notch parallel to axis 2 in. from center Transverse, notch perpendicular to axis 2 in. from center	4 4 4	4 4 4
Bend	Longitudinal	3	3	Longitudinal	C M	3 3	3 3	Longitudinal, M[e] Transverse, axis 1 in. from center, bend approximately 2 in. from center	3 2	3 2
Hardness (Brinell)	Longitudinal	1	1	Longitudinal	C M	1 1	1 1	Naval Experiment Station, at M Watertown Arsenal, used bend specimen	1 1	1 1

[a] Location of specimen:
C, at center of cross-section.
M, midway between center and circumference of cross-section.

[b] At two positions, 180 deg. apart.

[c] Torsion tests made only at Naval Experiment Station.

[d] At two positions, 120 deg. apart.

[e] At three positions, 120 deg. apart.

TESTS

All of the tests of the steels were carried out at the Naval Experiment Station and at Watertown Arsenal. In Table VI are summarized the various tests that were made together with the orientation of the test specimens with respect to the axis of the rounds and their location with respect to the center of the cross-section of the forging. At the Naval Experiment Station each of the three sizes in each of the two conditions of heat treatment were tested; at Watertown Arsenal only the 8-in. rounds were tested. The number of tests are also recorded in this table.

Mention may be made that the impact specimen used (Fig. 2) is not the one used ordinarily by American testing engineers. The other specimens were of the conventional type. The tension specimen was the usual 0.505-in. diameter specimen having a 2-in. gage length. The 6-in. bend specimen had a cross-section 1 by $\frac{1}{2}$ in. with the "outside" edges rounded off to a radius of $\frac{1}{8}$ in. The torsion specimen was $\frac{3}{4}$ in. in diameter with an over-all length of $9\frac{1}{4}$ in. and a test length of 5 in.; the length covered by the torsion meter was 3 in.

TEST DATA

The test data are summarized graphically in Figs. 3 to 10, inclusive. In correlating the test results with sulfur content, the Naval Experiment Station used the average sulfur content in the case of the 1-in. rounds, Figs. 3 and 4; the sulfur content for the center and midway positions, corresponding to the location of the test specimens, in the case of the 2-in. rounds, Figs. 5 and 6; and the general average sulfur content in the case of the 8-in. rounds, Figs. 7 and 8. This practice was followed in plotting the data, and in the case of the 2-in. rounds (Figs. 5 and 6) necessitates showing two sulfur values for each heat, one for the average sulfur at center and the other for average sulfur midway between center and circumference. Except in the case of two heats, D and G, the general average for the 8-in. rounds differed only slightly from the average sulfur content at the midway position, corresponding to the portion represented by the test specimens in nearly all cases. The Watertown Arsenal data for the 8-in. rounds were correlated by the committee, in the absence of any other correlation, with the average of the sulfur contents for the two midway positions (Figs. 9 and 10).

Attention is directed to the fact, as shown in Table IV and Figs. 7 and 8, that for the 8-in. rounds heats E and F are reversed in sequence as to sulfur content as determined at the Naval Experiment Station, compared to the sulfurs for these heats reported for the 1-in. and 2-in. rounds by the same laboratory.

It will also be noted that the range and distribution of sulfur for the eight heats in the 8-in. rounds as determined by the two laboratories differ somewhat. No attempt was made to reconcile the differences by averaging the results, since the purpose of the graphs correlating the properties and the sulfur contents is to establish *trends* and not absolute relationships.

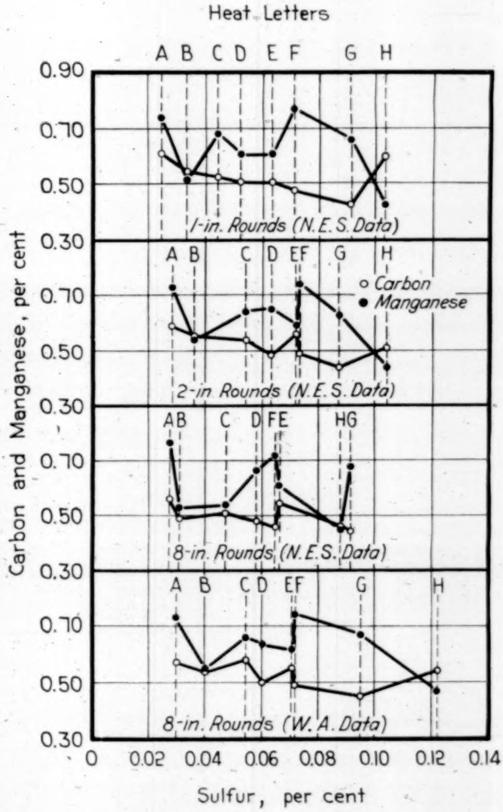


FIG. 1.—Variations in Carbon and Manganese, Heats A to H, inclusive.

Values shown for 2-in. and 8-in. rounds are from analyses taken midway between center and circumference of cross-section.

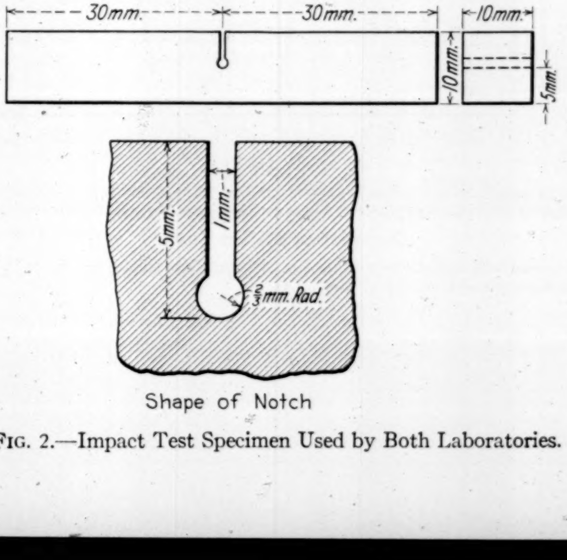

30mm.
30mm.
10mm.
10mm.
5mm.
1mm.
5mm.
$\frac{2}{3}$mm. Rad.
Shape of Notch

FIG. 2.—Impact Test Specimen Used by Both Laboratories.

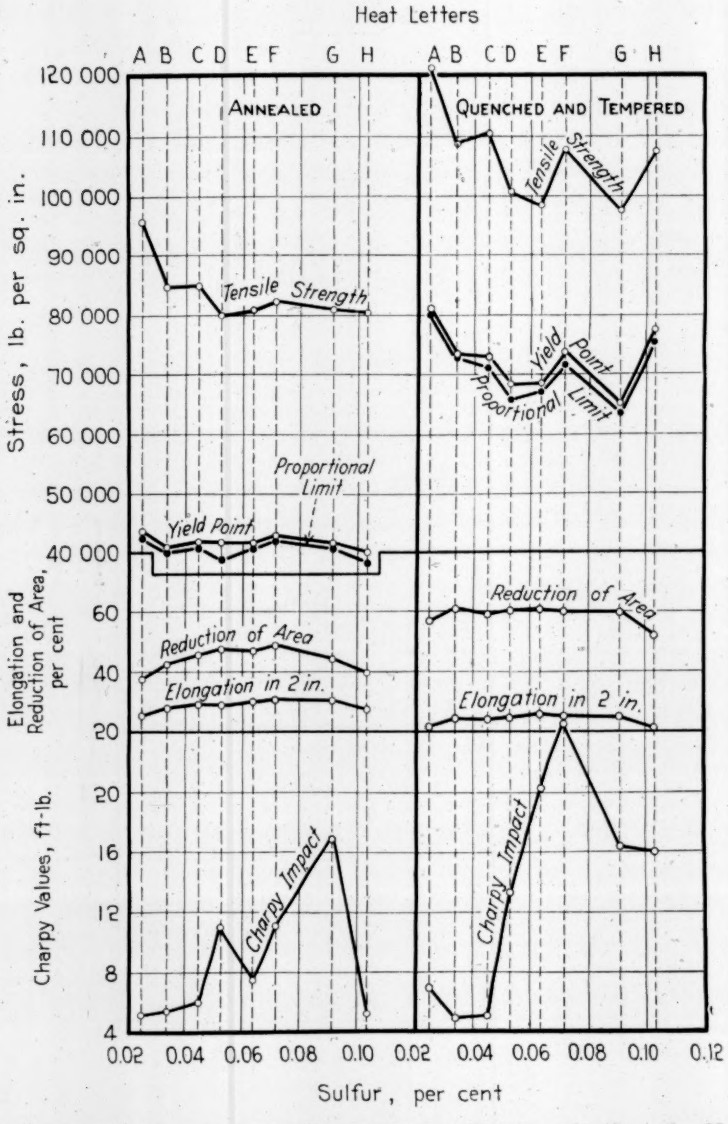


FIG. 3.—Tensile Properties and Charpy Impact Values, 1-in. Rounds, Naval Experiment Station Data.

For sulfur contents of respective heats used in plotting these graphs, see Table II.
Each plotted point is the average of three tests.

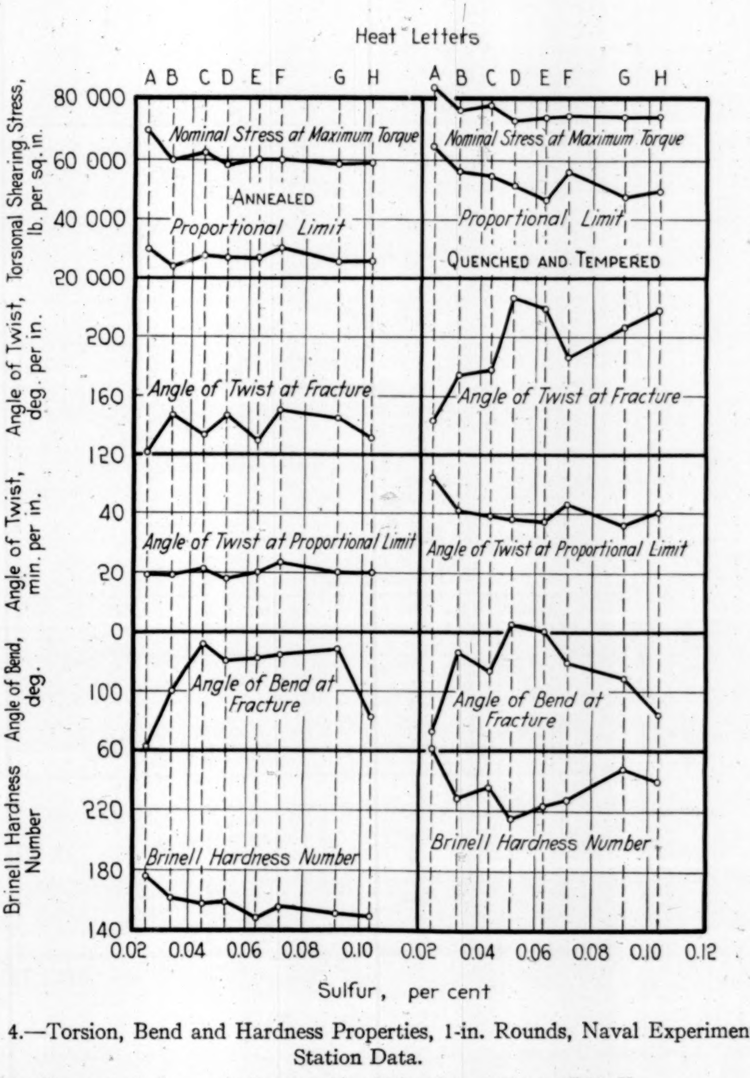


FIG. 4.—Torsion, Bend and Hardness Properties, 1-in. Rounds, Naval Experiment Station Data.

For sulfur contents of respective heats used in plotting these graphs, see Table II.

Each plotted point for torsion values is the average of two tests; for bend values, average of three tests; for hardness, one test.

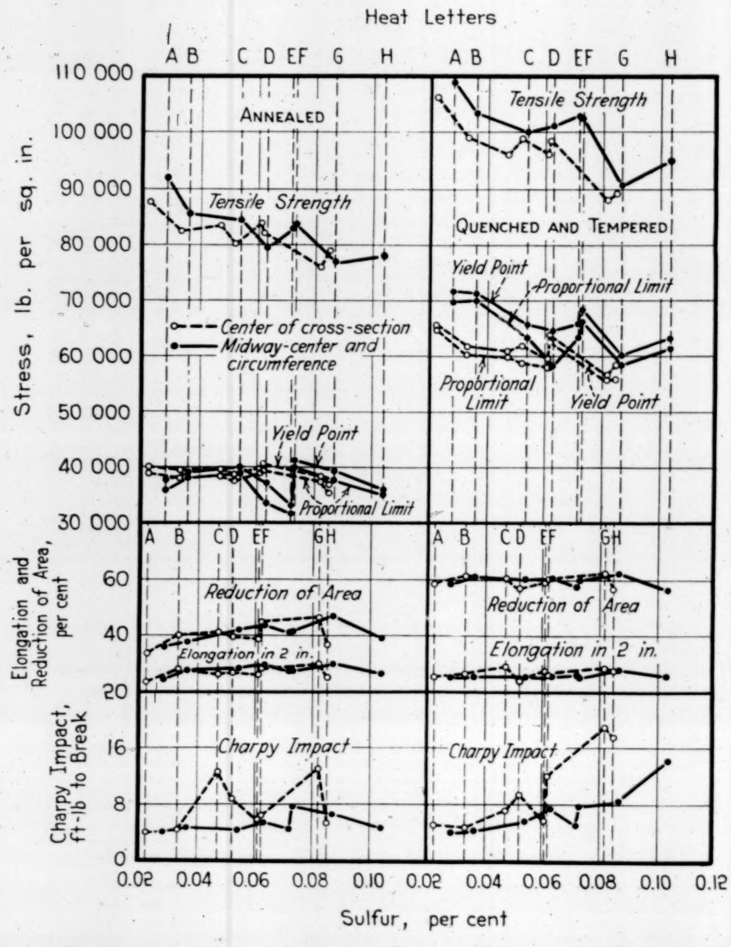


FIG. 5.—Tensile Properties and Charpy Impact Values, 2-in. Rounds, Naval Experiment Station Data.

For sulfur contents of respective heats used in plotting these graphs, see Table III. Each plotted point is the average of three tests.

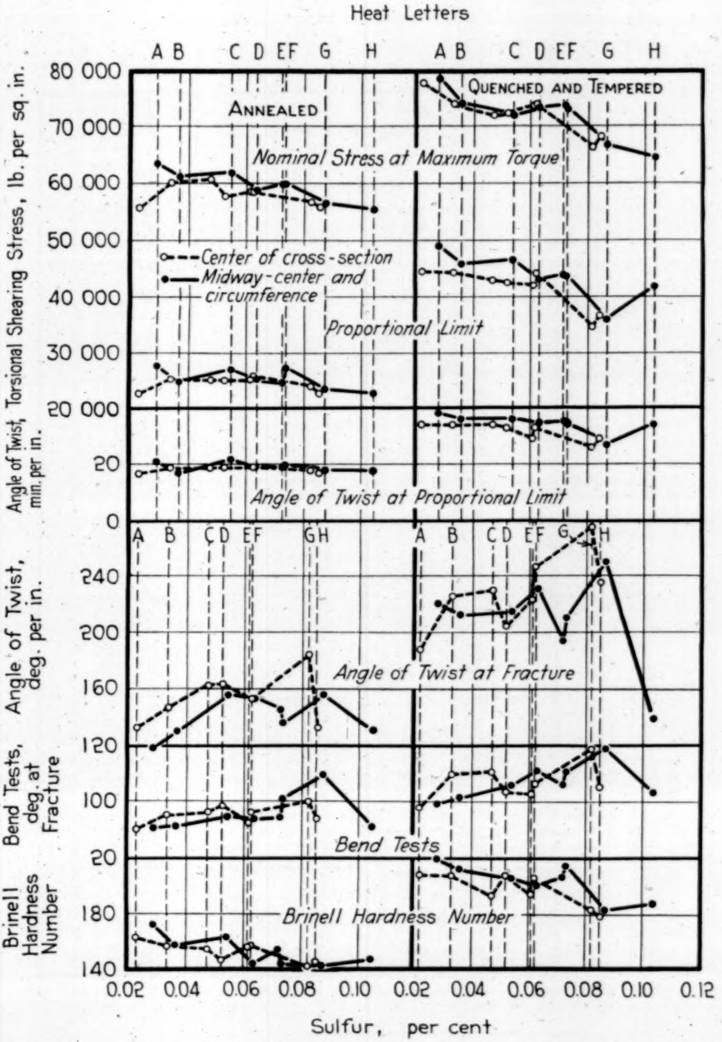


FIG. 6.—Torsion, Bend and Hardness Properties, 2-in. Rounds, Naval Experiment Station Data.

For sulfur contents of respective heats used in plotting these graphs, see Table III.

Each plotted point for torsion values is the average of two tests; for bend values, average of three tests; for hardness, one test.

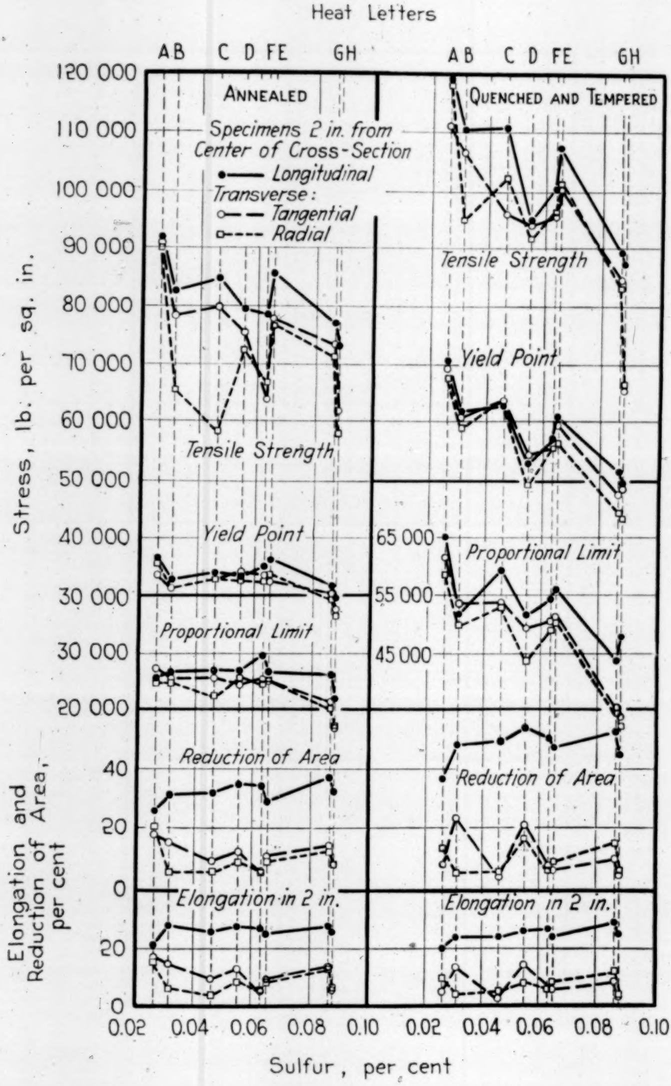


FIG. 7.—Tensile Properties, 8-in. Rounds, Naval Experiment Station Data.

For sulfur contents of respective heats used in plotting these graphs, see Table IV.

For location of specimens, see Table VI.

Each plotted point for longitudinal and transverse tangential values is the average of four tests; for transverse radial values, average of two tests.

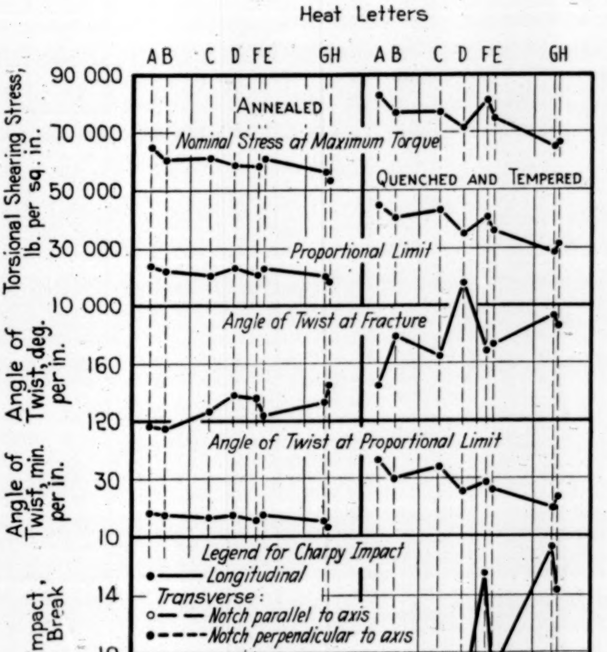


FIG. 8.—Charpy Impact Values, Torsion, Bend and Hardness Properties, 8-in. Rounds, Naval Experiment Station.

For sulfur contents of respective heats used in plotting these graphs, see Table IV.

For location of specimens, see Table VI.

Each plotted point for Charpy impact values is the average of four tests; for torsion values, and bend longitudinal values, average of three tests; for bend transverse values, average of two tests; for hardness, one test.

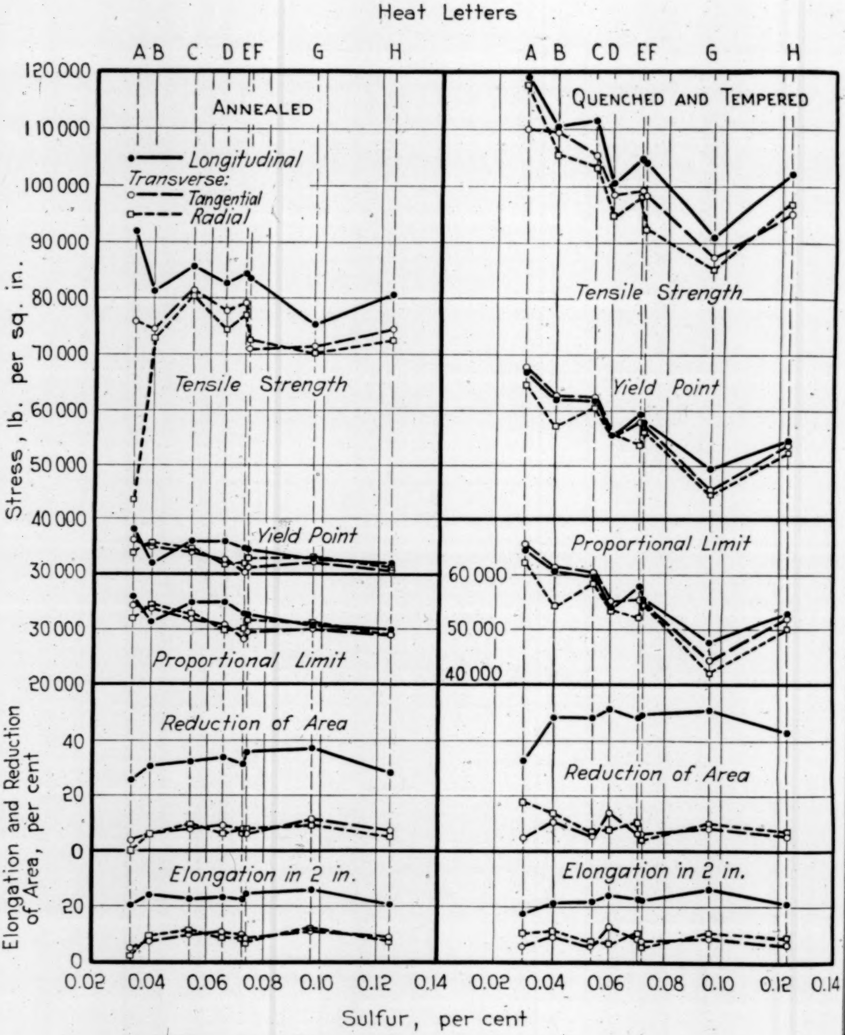


FIG. 9.—Tensile Properties, 8-in. Rounds, Watertown Arsenal Data.

For sulfur contents of respective heats used in plotting these graphs, see Table V.

For location of specimens, see Table VI.

Each plotted point for longitudinal and transverse tangential values is the average of four tests; for transverse radial values, average of two tests.

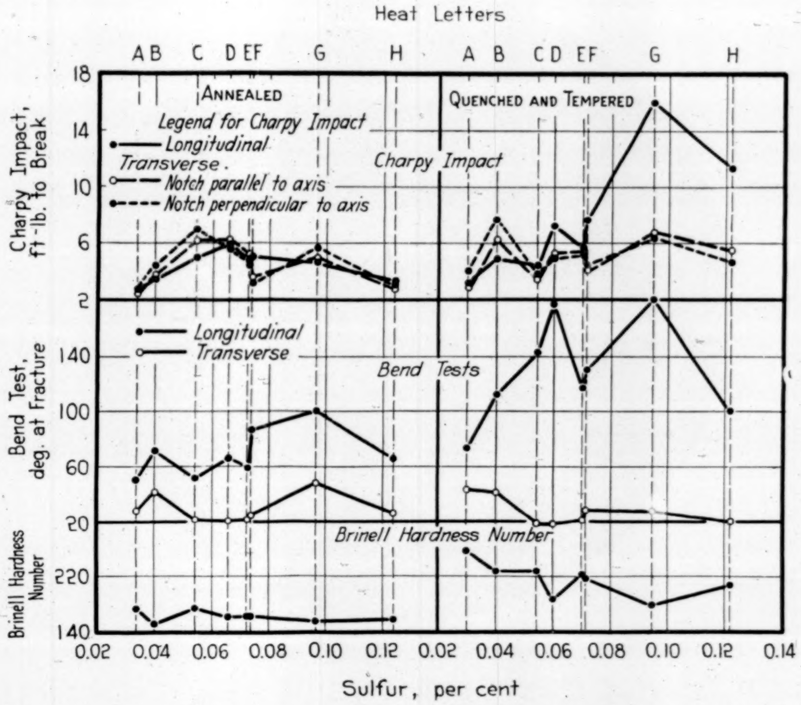


FIG. 10.—Charpy Impact Values, Bend and Hardness Properties, 8-in. Rounds, Watertown Arsenal Data.

For sulfur contents of respective heats used in plotting these graphs, see Table V.

For location of specimens, see Table VI.

Each plotted point for Charpy impact values is the average of four tests; for bend longitudinal values, average of three tests; for bend transverse values, average of two tests; for hardness, one test.

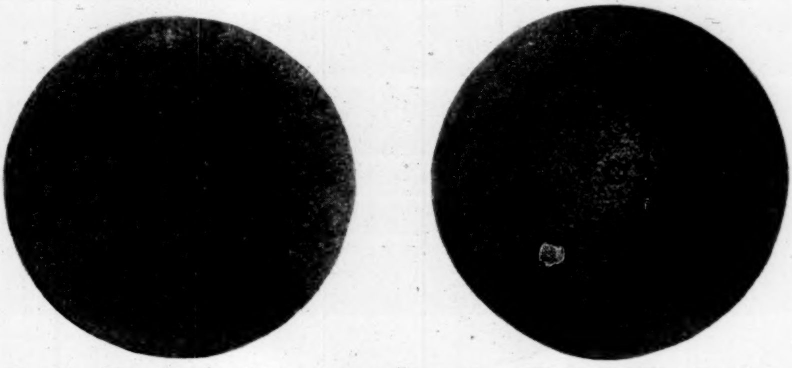


FIG. 11.—Macrographs of 2-in. Rounds, Heats A and H (Table III). Full Size.

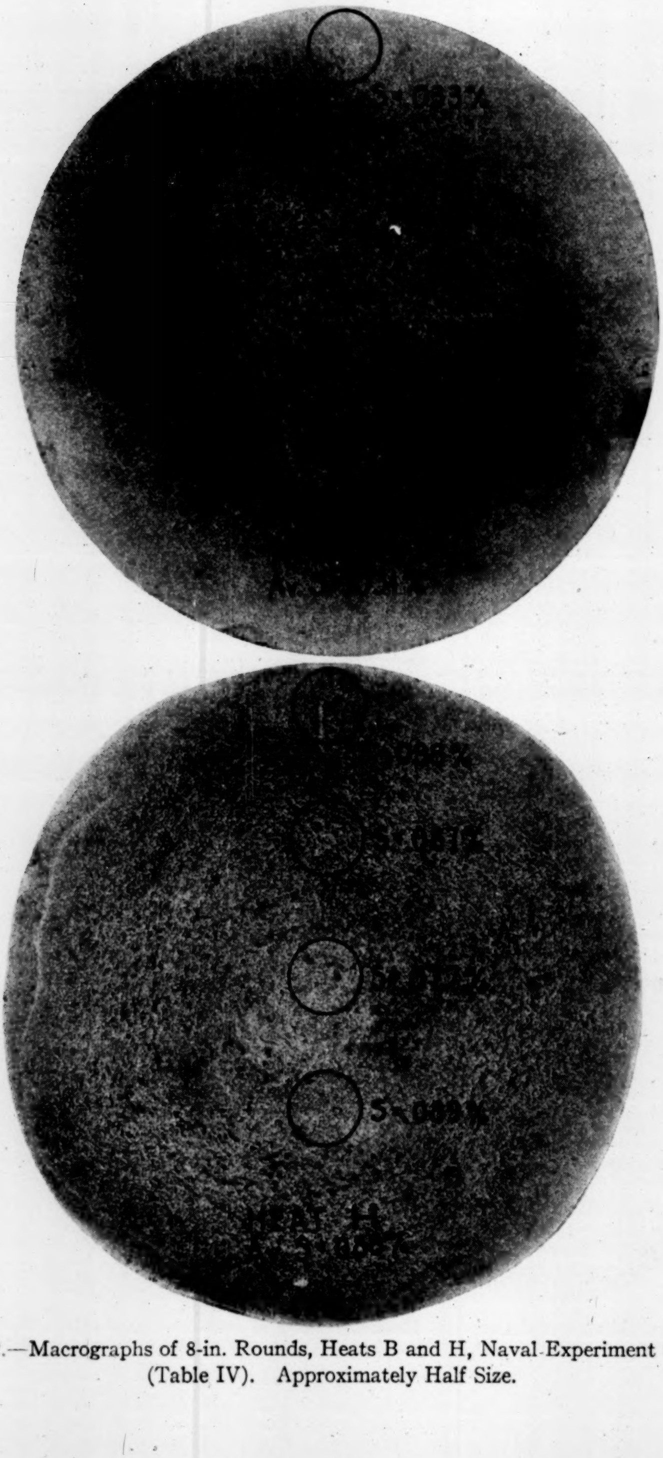


FIG. 12.—Macrographs of 8-in. Rounds, Heats B and H, Naval Experiment Station (Table IV). Approximately Half Size.

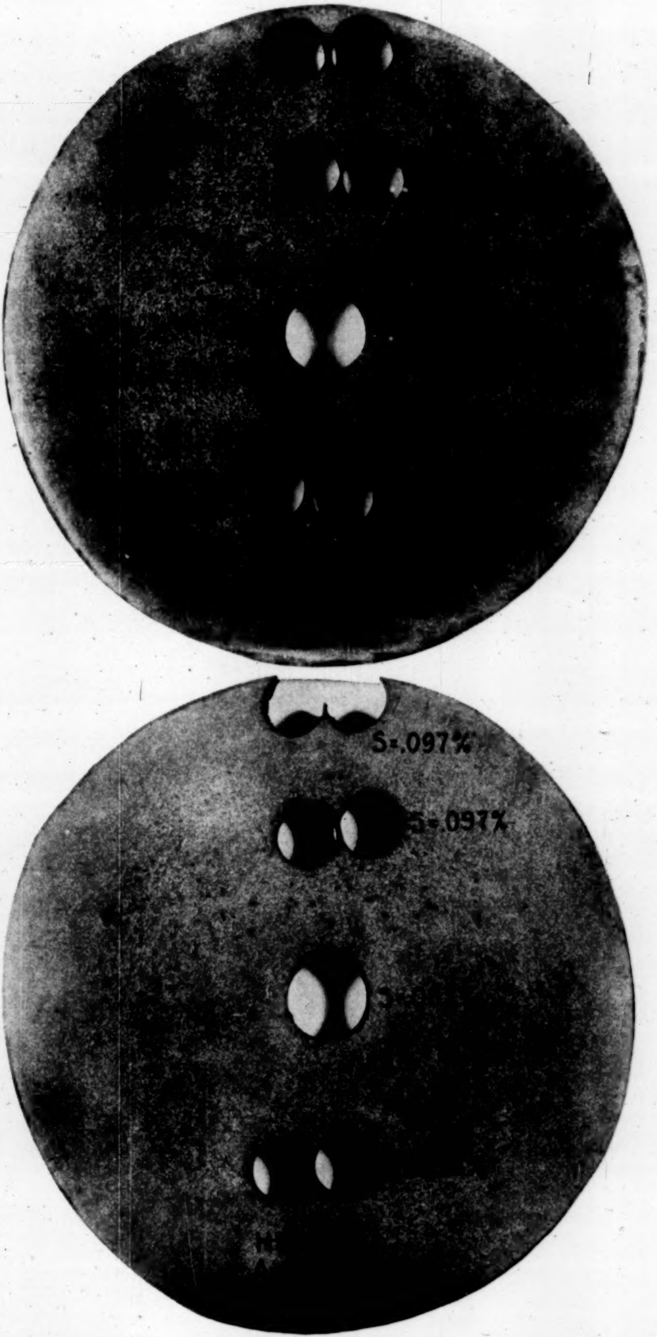
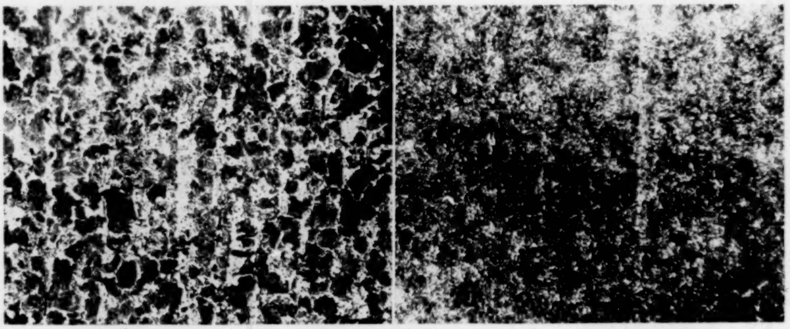


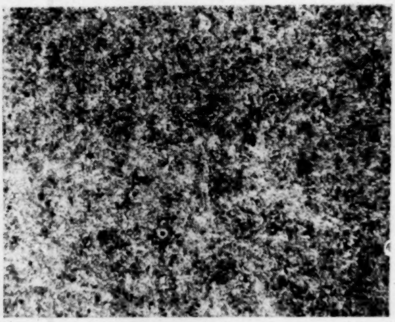
FIG. 13.—Macrographs of 8-in. Rounds, Heats A and G, Watertown Arsenal (Table V). Approximately Half Size.



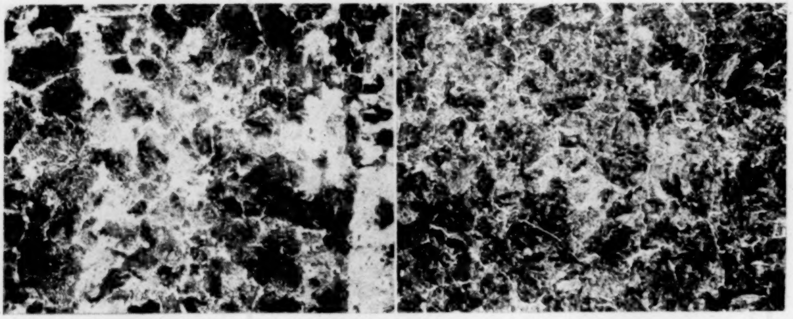
Annealed

Quenched and Tempered

1-in. Rounds



2-in. Rounds

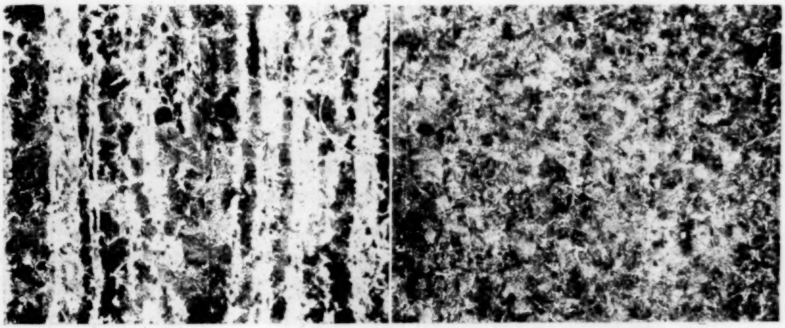


8-in. Rounds

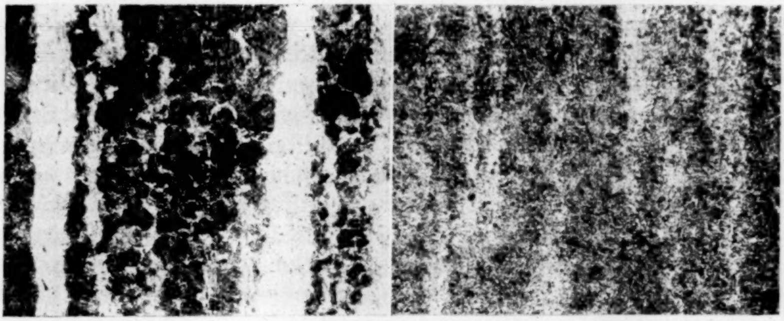
FIG. 14.—Microstructure of Low-Sulfur Steel, Heat B. Original Magnification × 100, reduced to × 75 in reproduction.

Etching Reagent: 2-per-cent alcoholic solution of nitric acid.

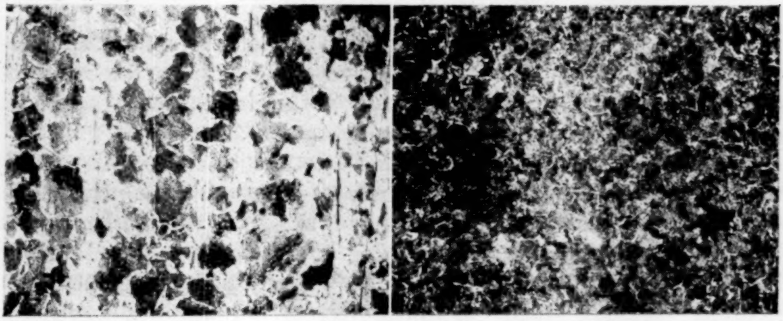
Annealed Quenched and Tempered



1-in. Rounds



2-in. Rounds



8-in. Rounds

FIG. 15 —Microstructure of High-Sulfur Steel, Heat H. Original Magnification × 100, reduced to × 75 in reproduction.

Etching Reagent: 2-per-cent alcoholic solution of nitric acid.

Structural Condition of Material.—The structural condition of all of the 8-in. and 2-in. forgings was examined by means of deeply etched cross-sections. The macrographs, Fig. 11, show the 2-in. forgings of minimum and maximum sulfur contents, heats A and H. Neither showed any structural features indicative of inferior quality. There was no marked non-uniformity in structure from center to circumference in either. These two forgings are representative, in their structural condition, of all the 2-in. rounds.

The 8-in. forgings, on the other hand, showed less uniformity in the structure across the section, undoubtedly because of relatively slight reduction in cross-section in forging. Typical macrographs of four heats are shown in Figs. 12 and 13. In some cases evidence of residual ingotism is to be seen in the deeply etched sections and in a few (for example, Fig. 13) suggestion of internal discontinuities.

Micrographs representative of the microstructure of two of the heats of low and high sulfur content in the three sizes are given in Figs. 14 and 15. The most striking structural feature is the "fiber" or "streakiness" which increases progressively with the amount of mechanical working received. This condition is also dependent upon the sulfur content, being much more pronounced in the high sulfur steel (heat H) than in the one of lower sulfur content (heat B). It will be noted that the inclusions, presumably sulfides, are largely associated with the ferrite streaks. Although this condition was much less apparent after quenching and tempering, it is evident that it was not entirely removed by such treatment.

DISCUSSION AND SUMMARY

The steels used were of plain carbon grade, such as are intended for ordinary use, and the conclusions expressed on the basis of the test results are not intended to apply to forging steels of a quality suitable for automotive and ordnance usage.

Certain apparently unavoidable variations in composition, aside from the intentional one in sulfur content, occurred in the preparation of some of the various heats. As shown in Fig. 1, the different heats when arranged in order of increasing sulfur content show a slight downward trend in carbon content. Variations in manganese also occurred but were much less uniform or systematic. In respect to the effect on the strength properties of the steels, variations in carbon content are of primary importance, followed next by variations in manganese content. Only those apparently systematic trends in the properties of any series which are so pronounced as to seem to be quite independent of the effect of these chance variations in carbon and manganese from the average, should be considered in drawing conclusions on the effect of sulfur on the properties of the steel.

The relatively slight reduction in cross-section by forging in the 8-in. rounds did not materially improve their structural homogeneity across the section. Evidence of ingotism was found, and, in addition, the macrographs of the deeply etched sections show in some cases apparent internal discontinuities. Since tests on transverse specimens from the 2-in. and 1-in. rounds were not made, the comparison of the 8-in rounds with the other forgings should be limited to the results obtained with longitudinal specimens. The transverse properties of the 8-in. rounds are useful, however, in illustrating directional variations in properties which may exist in relatively large forgings of this general character.

Comparison of the results obtained for a specific property, such as tensile strength, for the different sizes, shows noticeable differences in the three sizes. This can be most plausibly attributed to the increased mechanical working of those rounds of smaller diameter which resulted in greater structural uniformity (Figs. 11, 12 and 13) and is confirmed by the fact that the graphs for the properties of 1-in. rounds are considerably smoother than the corresponding curves for the other sizes.

In every case the possible influence of sulfur upon the properties of the steel was studied on both annealed and quenched-and-tempered steels. In most cases, the general observed trend in properties which might be associated with a progressively increasing sulfur content was accentuated by the quenching and tempering of the steel.

Consideration of the physical properties in relation to the possible influence of sulfur content within the limits covered leads to a classification of the graphs into three groups.

First, the curves summarizing tensile strength, proportional limit and yield point in tension, shearing stress at maximum torque and shearing stress at proportional limit in torsion, show a slight, though distinct, downward trend with increase in sulfur content. Though slight or negligible for the annealed steels, and especially for the 1-in. rounds, the trend is unmistakable in the quenched-and-tempered steels. The downward trend in these properties is consistent with the observed corresponding trend in carbon content. The fact that after quenching and tempering the downward trend was intensified is confirmatory of the effect of the variation in the carbon content. In the case of the smaller rounds in which the mechanical working received was sufficient to bring about structural uniformity, the decrease in the carbon content accompanying the progressively increasing sulfur content (Fig. 1) would seem to be sufficient to account for the observed downward trend in these properties. For the 8-in. forgings, however, this trend with increasing sulfur content was more pronounced than in the smaller rounds, although the change in carbon content was no greater. The conclusion would seem justified, therefore, that in this case the increase in sulfur content contributed to the somewhat lower strength properties obtained.

Second, the curves summarizing ductility of the steel in tension (reduction of area and elongation) and the angle of twist at the proportional limit in torsion, show no marked or significant changes which may be associated with changes in the sulfur content. Likewise, the ability of the steel to withstand severe deformation as shown by the angle of twist (at fracture) in torsion and the capacity for transverse bending (degrees at fracture) and the Brinell hardness were not adversely affected by increased sulfur content within the limits used.

Third, the curves summarizing the resistance to impact (Charpy test) of the various steels show the least consistent relationship of all the various properties in both the annealed and the quenched-and-tempered steels, either to the sulfur content or to other composition variations. Many more data would be required in order that a conclusion could be drawn concerning any possible general relationship.

In summarizing the data for the tests of all types, it may be stated of group III forging steels that the evidence, though less clear-cut than might be desired, shows no systematic relation between the increasing sulfur contents and the physical properties studied, and points to the conclusion that the physical effects of residual sulfurs in this grade of steel are of such low magnitude that they are masked by other more potent variables.

Respectfully submitted on behalf of the joint committee,

H. S. RAWDON,
Chairman.

C. L. WARWICK,
Secretary.

EFFECT OF ADDED PHOSPHORUS
ON
LOW-CARBON STEEL

REPORT OF THE JOINT COMMITTEE ON INVESTIGATION OF THE EFFECT OF PHOSPHORUS AND SULFUR IN STEEL

INTRODUCTION

Of the various studies of steels that have been made by the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel,[1] only one relates directly to the effect of phosphorus. This was on a low-carbon steel such as is used for the manufacture of pipe. According to the designations used in the committee's program,[1] this steel is referred to as series D, group I. The Association of American Steel Manufacturers in 1928 suggested[2] the desirability of tests to determine the possible effect of added phosphorus in low-carbon steel corresponding to the commercial practice of rephosphorizing in the manufacture of welded steel pipe. At about the same time, the American Petroleum Institute expressed its interest in a study of this kind, to be correlated with service tests to be carried out by the Institute on pipe made from steel of low and of high phosphorus content. This report summarizes the results of laboratory tests of four heats of low-carbon steel of progressively increasing phosphorus content.

MATERIALS

The four heats of steel, each approximately 95 tons, were made at the Lorain Works of the National Tube Co. in the presence of an Inspection Committee of the Joint Committee. To three of the heats, ferro-phosphorus was added in the ladle so as to give a progressively increasing phosphorus content. To the heat of lowest phosphorus content (heat A, Table I), no additions were made, the phosphorus content being entirely "residual."

The only detail of manufacture which would seem to have significant bearing on the properties as reported hereinafter is the difference in the amount of aluminum and ferrosilicon used as mold additions, when the ingot mold was two-thirds full. The following additions (total) were made to each heat.

---

[1] For a statement of the program of the committee, and a résumé of its origin and personnel, see *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 95 (1928).

[2] *Ibid.*, p. 102.

	HEAT A	HEAT B	HEAT C	HEAT D
Number of ingots	11	16	14	14
Aluminum, lb	40	45	55	42
Ferrosilicon (50 per cent silicon), lb	40	45	50	50

Heat C behaved in a somewhat irregular manner and a larger amount of aluminum was required in some ingots than in the others of this heat or in those of the other heats. The ingots representing the middle of the pouring (No. 7) and near the end (No. 13) showed great activity and additional aluminum was required.

The material set aside for the committee for test purposes was in the form of heavy skelp, 1 in. thick, 27 in. wide and 30 ft. long, the 1-in. thickness being necessary in order to obtain specimens of the requisite thickness for testing. The remainder of the steel from the four heats was manufactured into pipe which was furnished to the American Petroleum Institute for its own test purposes.

TABLE I.—CHEMICAL COMPOSITION OF STEEL.[a]

Each average given is based upon four determinations.

Heat Letter	Composition, per cent							
	Phosphorus	Carbon	Sulfur	Manganese	Silicon	Nickel	Copper	Chromium
A	0.007	0.10	0.029	0.47	0.01	0.016	0.02	0.005
B	0.051	0.10	0.030	0.49	0.02	nil	0.04	0.009
C	0.060	0.11	0.030	0.48	0.03	0.026	0.08	0.010
D	0.080	0.12	0.029	0.48	0.03	nil	0.02	0.014

[a] Chemical analysis by Naval Engineering Experiment Station, Annapolis, Md.

The composition of the four heats as determined on material furnished to the committee is summarized in Table I.

TESTS

The material was tested in three conditions, (1) as received, (2) annealed and (3) quenched. The heat treatment was carried out on pieces cut to the approximate size for test specimens. Annealing was done by heating in an electric-resistance muffle furnace to 1725 F. (940 C.), holding for one hour and cooling in the furnace. Quenching was done by heating in the same manner for one hour and then quenching in water (70 F., 21 C.).

The tests were made on specimens cut longitudinally and transversely from the skelp. The mechanical properties studied were believed to have a distinct bearing on the use of the steel for pipe

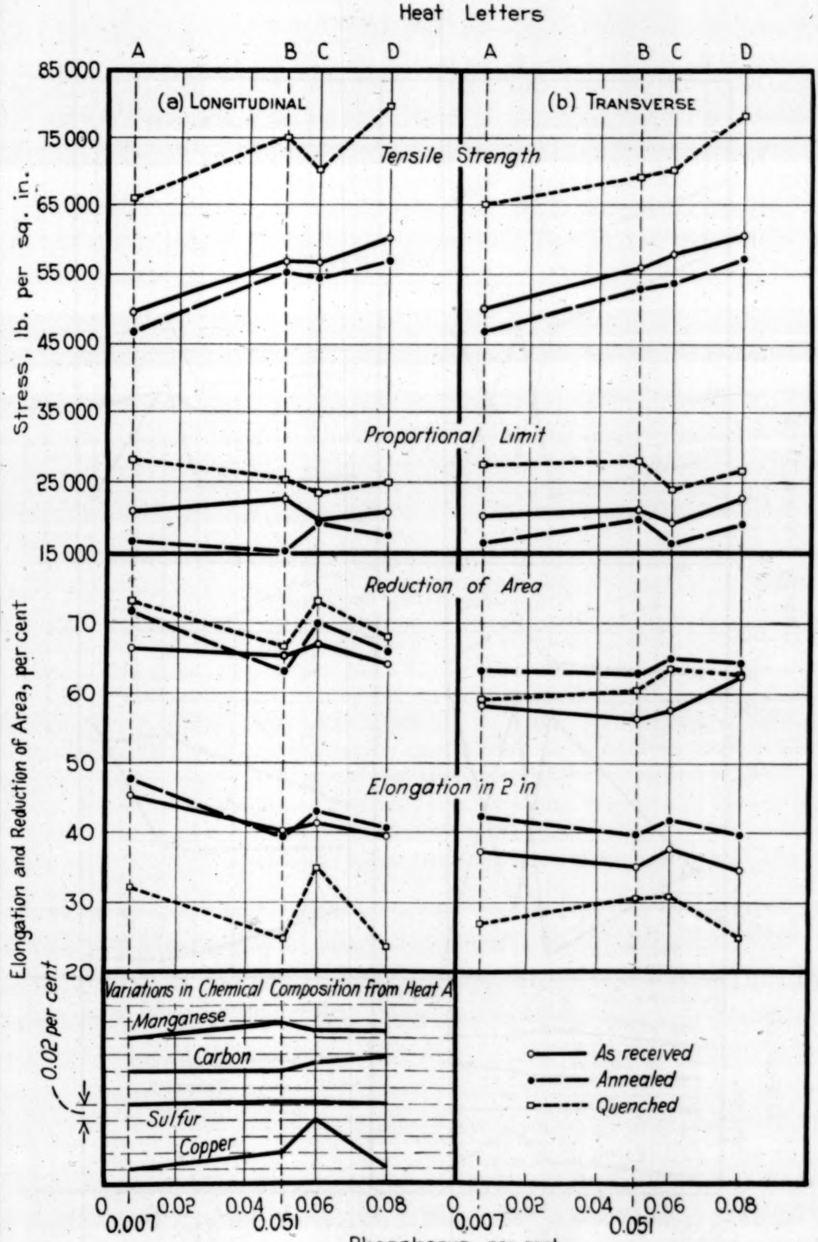


FIG. 1.—Effect of Phosphorus Content on the Tensile Properties of Low-carbon Steel.

Each plotted point is the average of three tests.

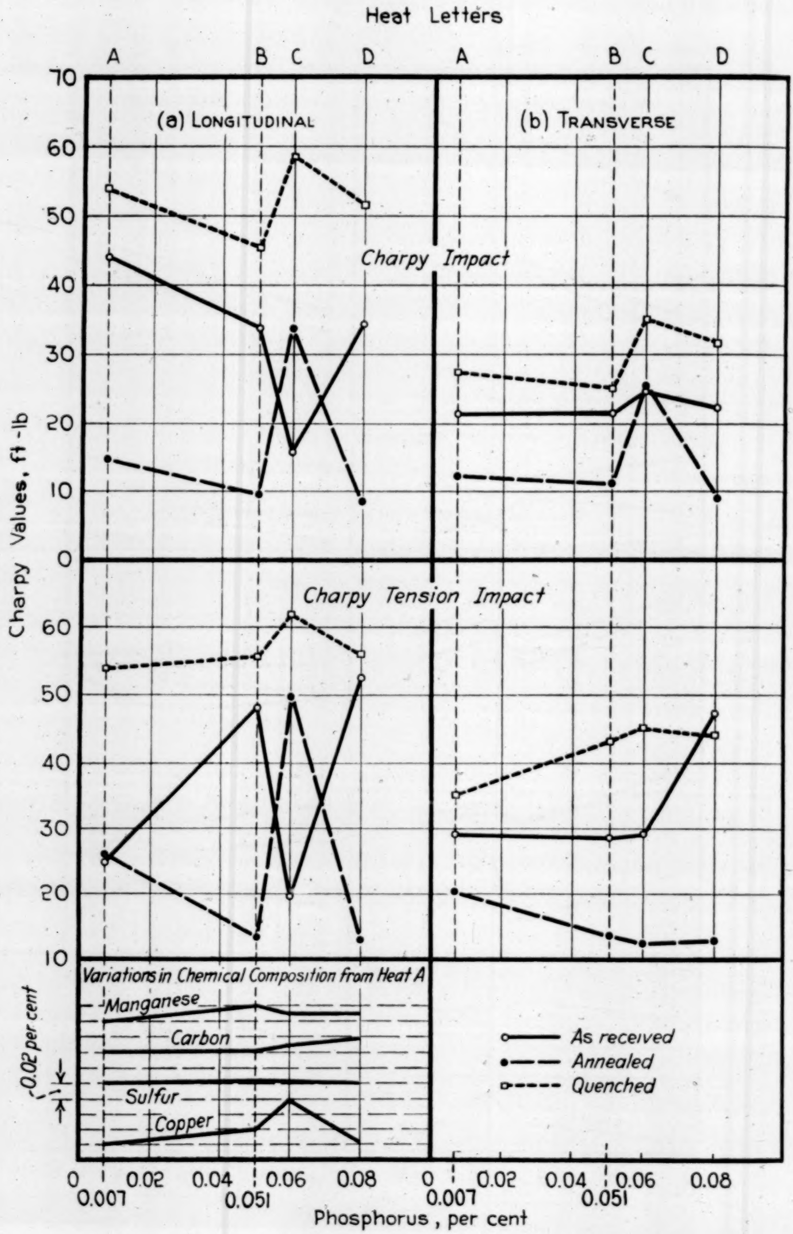


FIG. 2.—Effect of Phosphorus Content on the Impact Resistance of Low-carbon Steel.

Each plotted point is the average of three tests.

manufacture and included the tensile properties, resistance of notched bars to single-blow impact (Charpy impact test), resistance to tension impact (Charpy tension-impact test), cold bending and shearing. The usual tension test specimen, 0.505 in. in diameter with threaded ends, was used; the yield point was determined by "drop of beam," and the proportional limit from a stress-strain graph plotted on the basis of strain measurements made with an extensometer reading to 0.0001 in. In cold bending, a 6-in. strip having a cross-section of 1 by ½ in. with the "outside" edges rounded to a ⅛-in. radius was used. The shear test specimen was 0.250 in. in diameter.

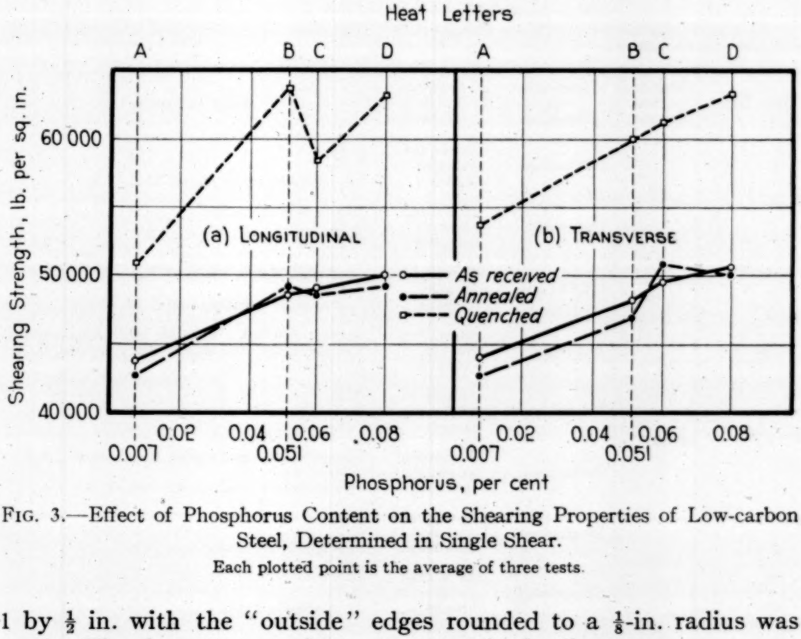


FIG. 3.—Effect of Phosphorus Content on the Shearing Properties of Low-carbon Steel, Determined in Single Shear.

Each plotted point is the average of three tests.

All of the mechanical tests on these steels were carried out by the U. S. Naval Engineering Experiment Station.

TEST DATA AND DISCUSSION

All the data (except results of cold bending) are presented in graphical form. In Fig. 1 are shown the average values (for each heat, type and condition) of the tensile strength, proportional limit, reduction of area and elongation in 2 in. In view of the more carefully determined values for proportional limit, the values for the yield point by "drop of beam" have not been included. Figure 2 gives average values for the two types of Charpy impact tests. The results of the shear test are given in Fig. 3. Each point plotted in the three figures is the average of three tests. The observations made on the steels under cold bending are given in Table II.

Structural Condition of Material.—The steel of heat C (0.06 per cent phosphorus) appeared with respect to its behavior under impact (Fig. 2) to be exceptional and not comparable with the companion heats. A structural examination of each of the three steels to which phosphorus had been added was accordingly made, the ends of broken impact specimens being used for the purpose. Typical micrographs are given in Figs. 4 and 5. The most pronounced and significant structural difference is to be seen in the three steels in the quenched condition. It is very evident that some other variable beside phosphorus content is an important factor in the case of heat C. The structure of the quenched sample of this steel suggests that its unusual structural condition is related to the so-called "structural abnormality" of steel which, in turn, is presumably to be associated with some unusual conditions obtaining during deoxidation, reference to which was made above (section on Materials). On account of the existence of this extraneous and unexpected variable,

TABLE II.—RESULTS OF COLD BEND TESTS.

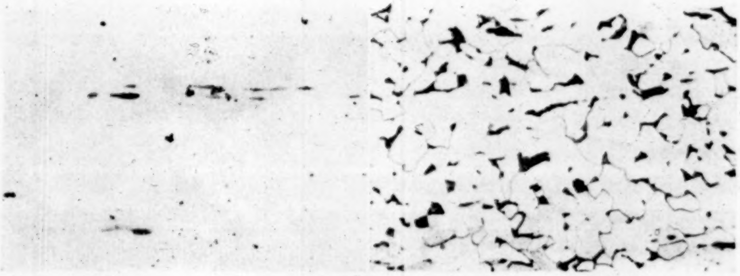
The specimen was bent through 180 deg. flat upon itself. Six specimens were tested in each case; that is, a total of 36 specimens for each heat.

Heat Letter	Phosphorus Content, per cent	Orientation of Specimen	Condition of Material	Result on Bending[a]
A	0.007	Longitudinal	As received	O. K.
			Annealed	O. K.
			Quenched	Two specimens, small cracks; four, O. K.
		Transverse	As received	Numerous small cracks
			Annealed	O. K.
			Quenched	O. K.
B	0.051	Longitudinal	As received	Small crack in one; others, O. K.
			Annealed	O. K.
			Quenched	Four specimens, cracks; two, O. K.
		Transverse	As received	One specimen O. K.; numerous small cracks in others.
			Annealed	Two specimens, small cracks; four specimens, O. K.
			Quenched	All specimens, cracks.
C	0.060	Longitudinal	As received	O. K.
			Annealed	O. K.
			Quenched	O. K.
		Transverse	As received	Two specimens, small cracks; four specimens, O. K.
			Annealed	O. K.
			Quenched	Four specimens, small cracks; two, O. K.
D	0.080	Longitudinal	As received	O. K.
			Annealed	O. K.
			Quenched	Four specimens, cracks; two, O. K.
		Transverse	As received	O. K.
			Annealed	O. K.
			Quenched	All specimens, cracks.

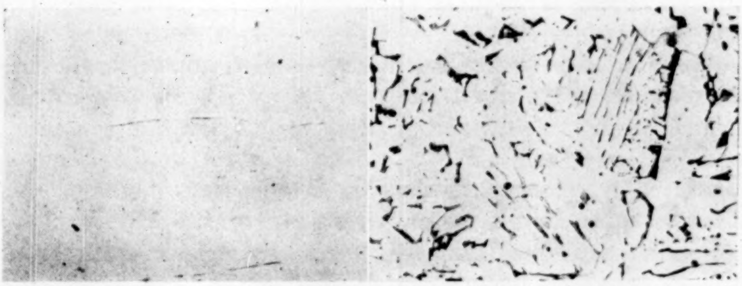
[a] O. K. indicates no cracks.

Annealed, unetched.

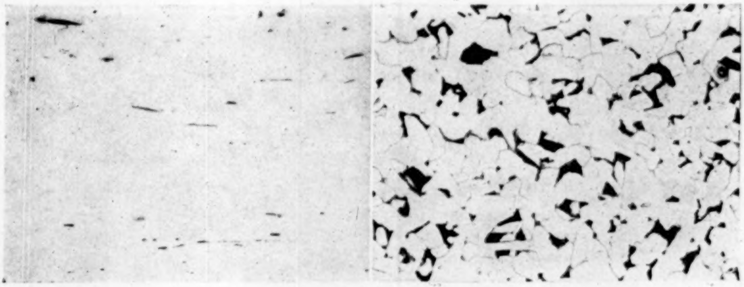
As received, etched with 1 per cent alcoholic nitric acid solution.



Heat B—Phosphorus 0.051 per cent.



Heat C—Phosphorus 0.060 per cent.



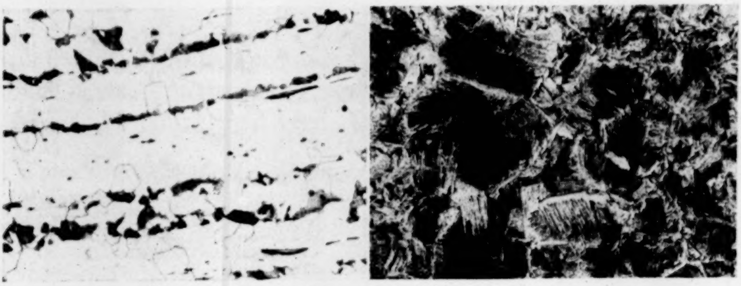
Heat D—Phosphorus 0.080 per cent.

FIG. 4.—Microstructure of Steels of Heats B, C, D. Original magnification, × 100, reduced to × 50 in reproduction.

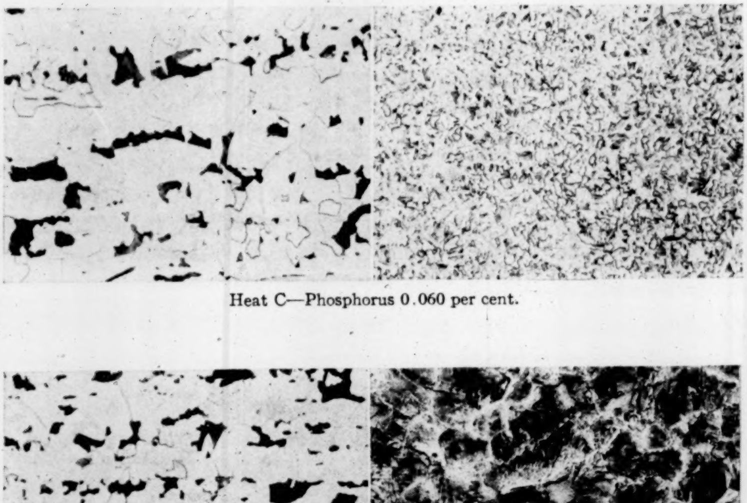
The difference in structure of heats B and D is very slight and is consistent with the fact that the impact resistance of the two differed only slightly (Fig. 2). On the other hand, heat C in the as-received condition had a lower impact resistance which is consistent with the general coarser grain structure and the lamellar form and distribution of the cementite.

Annealed at 1725 F. (940 C.).

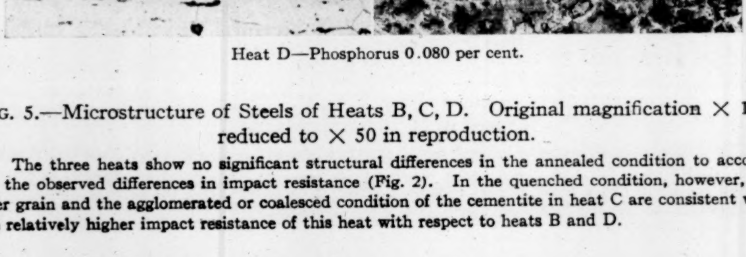
Quenched in water from 1725 F. (940 C.), etched with 1 per cent alcoholic nitric acid solution.



Heat B—Phosphorus 0.051 per cent.



Heat C—Phosphorus 0.060 per cent.



Heat D—Phosphorus 0.080 per cent.

FIG. 5.—Microstructure of Steels of Heats B, C, D. Original magnification × 100, reduced to × 50 in reproduction.

The three heats show no significant structural differences in the annealed condition to account for the observed differences in impact resistance (Fig. 2). In the quenched condition, however, the finer grain and the agglomerated or coalesced condition of the cementite in heat C are consistent with the relatively higher impact resistance of this heat with respect to heats B and D.

any attempt to establish a trend in the effect of increasing phosphorus content on the impact resistance should be based only on the heats which do give consistent results.

SUMMARY AND CONCLUSIONS

1. The results of the tests have shown an increase in tensile strength and a decrease in percentage of elongation with increasing phosphorus content, whereas in the case of the proportional limit and reduction of area a characteristic relationship has not been established. The shearing strength was affected, by increased phosphorus content, similarly to the tensile strength. Within the limits of phosphorus content used, an increase in phosphorus did not adversely affect the behavior of the steels under cold bending in the as-received or annealed conditions, but did have an adverse effect in the quenched condition.

2. The effect of some extraneous factor of far greater importance than the phosphorus content is shown by the results of the impact tests. This factor is in some way associated with some apparent "abnormality" of one of the steels as shown by the microstructure. This factor, however, has not affected the tensile properties determined to any significant degree, nor has the behavior of the steels under cold bending or shearing been noticeably affected.

3. There is a very satisfactory degree of uniformity between the tensile properties determined longitudinally (in the direction of rolling) and transversely to the direction of rolling.

4. On the basis of the tensile, shear and bending properties determined, all of the materials, regardless of the phosphorus content, are apparently good steels, well representative of this class of steel.

Respectfully submitted on behalf of the joint committee,

H. S. RAWDON,
Chairman

C. L. WARWICK,
Secretary.

DISCUSSION

MR. W. C. CHANCELLOR[1] (*presented in written form*).—The results are, taken as a whole, consistent and favorable to both the use of rephosphorized steel and the practice on such steels as applied by this company. We believe that the low impact values obtained on heat C in the as-rolled condition can be attributed more to a high finishing temperature than to structural abnormality. We base this statement on the large austenitic grain outline shown in the micrograph for heat C in the as-rolled condition. We also feel that the report places possibly too great an emphasis on the structure and physical properties obtained in the quenched and also in the annealed condition, for, when these steels are applied to pipe manufacture, the annealed and quenched conditions are very rarely encountered in practice. We are also inclined to feel that the emphasis placed on the structural abnormality on heat C may arouse considerable doubt in the minds of those not familiar with what is actually implied by this unfortunate term and the practical advantages and shortcomings of so-called abnormal and normal steels. At least so far as pipe is concerned, we do not believe that any evidence exists for considering the degree of structural normality an important factor.

MR. H. S. RAWDON[2] (*Chairman, Joint Committee on the Effect of Phosphorus and Sulphur in Steel*).—An examination of the microstructure of the steel will undoubtedly serve to support Mr. Chancellor in his statement that the low impact resistance of heat C can be attributed to the large austenitic grain size resulting from a high finishing temperature. That this is by no means a complete explanation is very apparent, however, on examining the microstructure of the steels after they have been annealed. Instead of rendering the three heats fairly uniform with respect to their impact resistance, as might be expected, annealing serves to emphasize in another way the anomalous impact properties of heat C. The difference in microstructure of the three heats after quenching, likewise, emphasizes the fact that heat C is in some respects fundamentally different from the comparison heats, B and D.

Most steel metallurgists will agree with Mr. Chancellor that the use of the term "abnormal" to describe a steel of this kind is indeed an unfortunate one. However, in spite of the discussion which this term has aroused and the objections raised to it, no better one has been evolved and the terms "normal" and "abnormal" have come to a well defined meaning in metallurgical parlance and to be fairly well established as metallurgical technical terms. Whether or not abnormality in pipe steel is of any practical importance is really an open question. To the writer's best knowledge, this is the first authentic example of this which has been described.

---

[1] Superintendent, Metallurgical Dept., Lorain Works, National Tube Co., Lorain, Ohio.

[2] Chief, Division of Metallurgy, National Bureau of Standards, Washington, D. C.

The desirability and the necessity for examining materials in any investigation of this kind in more than the one structural condition which generally obtains in service is illustrated by the case just mentioned. If one were to confine his observations on the impact resistance of the three comparison heats solely to the as-received steel, he would fall far short of a complete and true analysis of the situation and any explanation advanced on such incomplete analysis might be entirely erroneous or at best only partially applicable. In examining these materials in various conditions, the committee has followed the precedent established in the first work done by the committee on rivet steels in which it was realized that the importance of the subject demanded as complete an investigation as possible.

REPORT OF SECTIONAL COMMITTEE ON STANDARDIZATION OF DIMENSIONS AND MATERIAL OF WROUGHT-IRON AND WROUGHT-STEEL PIPE AND TUBING

FUNCTIONING UNDER AMERICAN STANDARDS ASSOCIATION PROCEDURE UNDER JOINT SPONSORSHIP OF A.S.M.E. AND A.S.T.M. (A.S.A. PROJECT: B36)

The Sectional Committee on Standardization of Wrought-Iron and Wrought-Steel Pipe and Tubing has held two meetings during the past year, the first in Chicago, Ill., in June, 1933, and the second in Washington, D. C., in March, 1934. This report is principally one of progress as the attention of the committee has been directed largely toward review of the criticisms received from industry and the corresponding revision of the proposed American Tentative Standard for Wrought-Iron and Wrought-Steel Pipe. The first draft of the proposed standard was published by the American Society of Mechanical Engineers in February, 1933, and subsequent revised drafts were printed under dates of June, 1933, and January, 1934.

In view of the fact that the proposed standard had been available for criticism in printed form for over a year, the committee voted at the March, 1934, meeting to accept, subject to a letter ballot of the entire committee, the January, 1934, draft with revisions for presentation to the sponsors with the recommendation that it be promulgated as an American Tentative Standard. The results of this letter ballot of the sectional committee, which consists of 39 members, are as follows: 31 members returned their ballots, of whom 30 voted affirmatively, none negatively and one marked his ballot not voting.

A few changes in the proposed standard also were approved on the letter ballot. The most important of these calls for the omission of Appendices B and C. Appendix B consists of a table on dimensions and weights of lap-welded and Grade A seamless steel pipe for high-temperature steam service, appearing in the Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 33 T) of the American Society for Testing Materials,[1] while Appendix C is a table of pressure-temperature ratings for power piping applicable to Appendix B.

The following A.S.T.M. pipe specifications, which were accepted by the sectional committee for submission to the American Standards

---

[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 33, Part I, p. 572 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 114.

Association for approval as American Standards or American Tentative Standards, were approved by the Joint sponsors, the A.S.M.E. and the A.S.T.M., and have recently been approved by the A.S.A.:

Approved as American Standards:

Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 33) (A.S.A. No.: B36.1 – 1934)

Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 33) (A.S.A. No.: B36.2 – 1934)

Approved as American Tentative Standards:

Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 33 T) (A.S.A. No.: B36.3 – 1934)

Tentative Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 30 in. and Over) (A 134 – 32 T) (A.S.A. No.: B36.4 – 1934)

Tentative Specifications for Electric-Resistance-Welded Steel Pipe (A 135 – 32 T) (A.S.A. No.: B36.5 – 1934)

Tentative Specifications for Forge-Welded Steel Pipe (A 136 – 32 T) (A.S.A. No.: B36.6 – 1934)

Tentative Specifications for Lock-Bar Steel Pipe (A 137 – 32 T) (A.S.A. No.: B36.7 – 1934)

Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 32 T) (A.S.A. No.: B36.8 – 1934)

Tentative Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139 – 32 T) (A.S.A. No.: B36.9 – 1934)

Respectfully submitted on behalf of the sectional committee,

H. H. MORGAN,
Chairman.

SABIN CROCKER,
Secretary.

REPORT OF COMMITTEE A-2
ON
WROUGHT IRON

Committee A-2 on Wrought Iron held one meeting this year at the Wardman Park Hotel, Washington, D. C., on March 9, 1934. A second meeting will be held prior to the presentation of this report to the Society when the report will be reviewed and other matters considered.

RECOMMENDATIONS AFFECTING STANDARDS

The recommendations of the committee affecting standards are presented first in summarized form, together with an analysis of the letter ballot on each item. They are then further referred to under subcommittee activities, being grouped for convenience in the order of the respective subcommittees responsible for them.

I. Proposed Revision of Standards.—The committee recommends that the revisions in the following two standards, as proposed in the reports of the respective subcommittees, be issued as tentative revisions:

Standard Specifications for Hollow Rolled Staybolt Iron (A 86 – 30), revision proposed by Subcommittee III;

Standard Specifications for Wrought-Iron Plates (A 42 – 30), revision proposed by Subcommittee IV, in the form of new tentative specifications.

II. Adoption of Tentative Standard as Standard.—The committee recommends that the Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 32 T) be approved for submission to letter ballot of the Society for adoption as standard.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 54 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF STANDARDS			
Specifications for Hollow Rolled Staybolt Iron (A 86 – 30)	39	0	5
Specifications for Wrought-Iron Plates (A 42 – 30)	38	1	5
II. ADOPTION OF TENTATIVE STANDARD AS STANDARD			
Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 32 T)	37	0	7
III. INFORMATION FOR PUBLICATION			
Report of Subcommittee X on Quality Standards for Wrought Iron	42	0	2

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Tubes and Pipe (G. H. Woodroffe, chairman).—Subcommittee I concurs in the recommendation that the Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 – 32 T)[1], which are under the joint jurisdiction of Committee A-1 on Steel and Committee A-2, be adopted as standard.

Subcommittee III on Staybolt and Engine-Bolt Iron (E. J. Edwards, chairman).—This subcommittee is recommending for publication as a tentative revision of the Standard Specifications for Hollow Rolled Staybolt Iron (A 86 – 30),[2] the changes indicated below:

Section 11.—Change the center heading, "Permissible Variations in Gage," which precedes this section, to read, "Permissible Variations."

Add the following sentence as Paragraph (*b*), lettering the present section as Paragraph (*a*):

> (*b*) The diameter of hole shall be $\frac{3}{16}$ in. within a permissible variation of -0 and $+\frac{1}{32}$ in. A rod $\frac{1}{8}$ in. in diameter shall pass freely through the entire length of the tell-tale hole. The tell-tale hole may be off center $\frac{1}{16}$ in., maximum.

Subcommittee IV on Plates, Shapes and Sheets (James Aston, chairman).—This subcommittee has developed an extensive revision of the Standard Specifications for Wrought-Iron Plates (A 42 – 30)[3] in the form of new tentative specifications, appended hereto,[4] which are recommended for publication as tentative to replace, when adopted, the present standard specifications. The principal features of the revised specifications will be (*a*) the elimination of plates of any quality not conforming to standard definition of wrought iron, (*b*) revision of physical properties to recognize that by appropriate rolling practice the transverse physical properties of wrought-iron plates may be increased with, however, a proportionate reduction in the longitudinal properties, this relation being covered by a formula and table, (*c*) defining the scope to include bending or similar fabricating requirements, and (*d*) insertion of thickness and weight tolerance limits.

Subcommittee X on Research (J. H. Higgins, chairman).—This subcommittee has prepared a report on Quality Standards for Wrought Iron which, while in no sense a specification, contains much valuable information to the wrought iron industry as a whole. In view of the importance of this work the subcommittee recommended that it be published and it is accordingly appended to this report.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 586 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 107.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 443.

[3] *Ibid.*, p. 459.

[4] See p. 648.—ED.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee, which consists of 54 members; 42 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. W. FAUS,
Chairman.

G. H. WOODROFFE,
Secretary.

EDITORIAL NOTE

The proposed revision of the Standard Specifications for Hollow Rolled Staybolt Iron was accepted for publication as tentative and appears on page 1258.

A revision of the Standard Specifications for Wrought Iron Plates in the form of new tentative specifications was accepted for publication as tentative. The specifications in their revised form appear on page 648.

The Tentative Specifications for Riveted Steel and Wrought-Iron Pipe were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, page 50.

The report on Quality Standards for Wrought Iron presented by Subcommittee X was approved for publication and appears on page 129.

QUALITY STANDARDS FOR WROUGHT IRON

REPORT OF SPECIAL SUBCOMMITTEE OF SUBCOMMITTEE X ON RESEARCH

Prior to 1930, the specifications of the American Society for Testing Materials, applying to quality wrought iron products, designated a material made by puddling. It was recognized that this requirement failed to take account of the fact that wrought iron had been made by several methods other than puddling in its long history and development; that recent important developments in manufacture had taken place; and that changes in process might be expected in the future or with progressive advancement of the industry. Furthermore, for products bought or inspected at points remote from the place of manufacture, there was no means of identification of process, except through the medium of the manufacturer's brand upon the articles, and a faith in and approval of his methods of production.

In 1930, Committee A-2 on Wrought Iron of the Society departed from the plan of designating the permissible method of manufacture and defined wrought iron as a characteristic material, as follows:

> *Wrought Iron.*—A ferrous material, aggregated from a solidifying mass of pasty particles of highly refined metallic iron, with which, without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag.

Material made in accordance with the above definition or having the characteristics resulting from such procedure will be wrought iron of quality. There is excluded, on the one hand, steel, no matter how pure, because of an absence of "minutely and uniformly distributed slag"; and on the other hand, adulterated material resulting from scrap busheling, because of failure to "aggregate from a solidifying mass of pasty particles." However, there are technical features involved in the definition which necessitate the setting up of standards or limits for determination of quality.

This report is a cooperative effort of Committee A-2 members to bring about a better understanding among users of wrought iron concerning its underlying characteristics, the meaning of test results, and the various factors by which the quality may be judged.

The definition given above is specific in its purposes and results, and accurately defines wrought iron of recognized characteristics as to quality. It is, however, a technical definition which involves features of refinement of base metal and character of slag distribution which may be set only by experience or comparison. Physical properties, chemical composition, and internal structural characteristics are the important features by which one may determine quality, or distinguish it from other classes of ferrous materials. The following discussion embodies the fundamental points among the several features involved.

PHYSICAL PROPERTIES

The determination of the physical properties of wrought iron, such as strength, ductility, and elasticity, may not entirely reflect the finer points of quality, or serve to distinguish it from adulterated wrought iron or soft grades of steel. However, the physical properties are important in the selection and adaptability of materials for different services, and a consideration of typical properties is of great value in an understanding of the product.

The physical properties of wrought iron are largely those of pure iron. The strength, elasticity, and ductility are affected to some degree by small variations in the metalloid content, and in even greater degree by the amount of the incorporated slag and the character of its distribution. Up to certain limits, the ductility is increased by extra working, due to its effect in causing a finer distribution and more thread-like character of the incorporated slag. This may be accomplished in practice by the large reduction of section obtained in rolling or forging large initial blooms into proportionately small final sections; or by rolling smaller initial masses to bar sections, which are in turn built into "piles," heated to welding temperature and rolled to desired forms. In common practice this is done once for "single refined" wrought iron and twice for "double refined" products.

The properties of wrought iron, in common with other ferrous types, are influenced by the composition. Carbon content, either through incomplete elimination or where steel scrap may be used in adulteration in "busheling" or in making up piles, is reflected in increased tensile strength and elastic limit. Phosphorus acts in a somewhat similar fashion, and has the marked effect of promoting brittleness under high heat influences, such as result from welding pipe.

The physical properties of wrought iron, unlike those of steel, are markedly different in a direction transverse to rolling as compared with those in the longitudinal direction, due to the nature of the slag distribution in the two directions. The transverse strength and ductility are materially lower than the longitudinal properties, depending to a large extent upon the rolling history. By proper equalization of rolling in the usual longitudinal and transverse directions, it is possible to effect an equalization of the customary directional properties. Recognition must be given that such practice results in intermediate values for ultimate tensile strength and elongation between those normally resulting in longitudinal and transverse directions. This feature is exemplified in the Tentative Specifications for Wrought-Iron Plates (A.S.T.M. Designation: A 42 - 34 T) of the American Society for Testing Materials.[1] It has a particular bearing in connection with flanging or forming operations.

The reader is referred to the specifications for various wrought-iron products, which are embodied in the standards and tentative standards of the American Society for Testing Materials. The standards appear in the Book of A.S.T.M. Standards, issued triennially, the current edition being that of 1933. Standards in their formative stage are published as tentative for one or more years and appear in the annual *Proceedings* for the year in which they are issued or revised and are also published collectively in the Book of A.S.T.M. Tentative Standards, issued annually.

CHEMICAL ANALYSIS

The commonly given analysis of wrought iron lists carbon, manganese, phosphorus, sulfur, and silicon. However, since wrought iron is a composite material consisting of an intermingling of base metal and slag, and since the above constitutents are distributed in greater or less degree between the metal and slag, it will be realized that the desirable analysis is one which discloses this distribution. Analyses for determination of slag quantity have been developed and progress is being made on methods whereby the position and amount of the several elements in metal and slag may be determined. As yet they are not adapted to usual laboratory procedure. The following general comments may be made:

Carbon:

The carbon content is usually lower in wrought iron than in steel, but it is not lower than in the class of open-hearth product known as ingot iron. The refining is carried to a high degree and the additions commonly made in finishing a heat of steel are not made in the manufacture of wrought iron. Consequently, quality wrought iron has usually been associated with low-carbon content,

---

[1] See p. 648.—ED.

0.02 or 0.03 per cent being quite typical. However, much high quality wrought iron has a carbon content of 0.08 or even 0.10 per cent. Higher amounts may be an indication of imperfect or incomplete refining (raw iron) or may awaken a suspicion that steel scrap has been used in busheling or piling. However, if carbon of higher than customary amount could be retained in or added to wrought iron, without losing the inherent characteristics of this product, benefit might be derived in certain uses due to higher tensile properties resulting.

Manganese:

The element manganese is quickly eliminated in customary iron and steel refining reactions. Its presence in steel in relatively large amounts, 0.30 to 0.75 per cent, is the result of additions made necessary to counteract deleterious effects of the refining operation. In wrought iron manufacture, no such additions are made; consequently, well made wrought iron usually has a manganese content below 0.05 per cent. Higher manganese might be the residual resulting from imperfect refining of a relatively high manganese charge; or it may indicate adulteration by the use of some steel in busheling or piling. Manganese above 0.10 per cent in wrought iron is quite indicative of a mongrel product.

The virtual absence of manganese in wrought iron, and its almost universal presence in steel, has resulted in the manganese determination being used as a means of identification and differentiation. With adulterated products, due to averaging the mixture of wrought iron and steel, some uncertainty may arise in identification; likewise ingot iron (open-hearth iron) has a low manganese content conforming to usual wrought iron characteristics.

While manganese has been blamed as a factor promoting increased corrosion, it is doubtful if it deserves the stigma. Also, it is quite probable that quality wrought iron carrying higher manganese would gain in strength and ductility without material loss in its other desirable attributes.

Phosphorus:

The phosphorus content is almost invariably higher in wrought iron than in steel. It is in part alloyed with the base metal and in part associated with the slag. In excellently made wrought iron, the phosphorus may be 0.10 per cent or even less; and again it may be 0.25 per cent or more. The differences are linked with the character of charge material, with some of the refining reactions, and with the intended purpose of the product. They are not a criterion of quality of product, but rather of manufacturer's preference. In general, it may be stated that the lower order of phosphorus is advisable for products where higher ductility is desirable; where shock is a service factor, or where high heat effects might leave residual brittleness. However, it is the phosphorus content of the base metal which is primarily responsible for these effects and, consequently, the distribution of the element is a most important factor.

Sulfur:

The element sulfur is always undesirable and is a promoter of "red-shortness" and corrosion. In well-made wrought iron it should not exceed 0.05 per cent, and it is usually less than 0.03 per cent.

Silicon:

The element silicon is quickly removed in the refining of iron and steel, and the oxidized product becomes an important constituent of refining slags. In steel analyses, that noted in the final product is an added amount alloyed with the metal. In wrought iron, it is almost entirely a constituent of the slag. The usual silicon content is between 0.10 and 0.20 per cent. It varies with the nature and quantity of the incorporated slag and to a considerable degree it is governed by the preference of the individual manufacturer and by the nature of the finished product. Repeated working of wrought iron tends to reduce the slag quantity; with a progressive lowering, other things being equal, of the silicon content of the wrought iron as a whole.

STRUCTURAL CHARACTERISTICS

In view of the fact that wrought iron is a composite material, methods of examination which reveal the character of association between metal and slag are of paramount importance in identification and determination of quality. Such evidences may be visible to the naked eye (macroscopic) or may necessitate the use of higher powers of the microscope.

Macroscopic Examination:

The nick bend, or fracture test, has long been a favorite way of rapidly distinguishing wrought iron from steel. The former exhibits a well-known fibrous fracture, as contrasted with a crystalline break of the latter. At times there may be confusion, since dirty steel may show a semblance of fiber; while on other occasions good wrought iron may break with a pseudo-crystalline fracture, due to high carbon, high phosphorus, overheating, or sudden break. Where the material is in question because of suspicion of scrap adulteration, the fracture test is of doubtful value and is liable to be misleading, if it is the sole reliance for basing judgment.

Deep etching with acid is a prevalent inspection method in selection of wrought iron products; particularly (1) as a means of disclosing method of piling, etc.; and (2) for the detection of adulteration with steel scrap. Wrought iron etches deeply, with a roughened, stringy or woody surface; whereas, steel will show a comparatively smooth surface. Consequently, a mixture of wrought iron with steel will exhibit a mixed type of surface, if the distribution is sufficiently coarse to be discernible. The etch test is a useful aid in the relatively rapid determination of adulterated wrought iron, and it has some value in detecting coarse slag pockets; but it is not of great assistance in the determination of the finer points of quality. Recommended etching agents are noted in several specifications of the Society.[1]

Microscopic Examination:

The slag in wrought iron has a thread-like distribution in the metallic matrix; it is uniformly disseminated and there will be a few hundred thousand filaments per square inch in well-worked wrought iron. It is but natural, therefore, that the microscope has become the most useful adjunct in the study of wrought iron and in fixing quality standards. Preparation by polishing and etching follows the general procedure used in metallographic study.

The microscope will disclose:

(*a*) Pearlitic areas due to carbon and resulting from incomplete refinement in prevalent methods of manufacture of wrought iron, or from adulteration with steel scrap of moderate carbon content. The manner of distribution of the carbon will quite generally serve to distinguish between these two causes.

(*b*) Type of slag and its distribution; such as coarse slag pockets, fine textures resulting from heavy rolling reductions, or the absence of normal slag content in raw or "steely" areas.

(*c*) Unusual characteristics of structure, such as coarsened grain caused by overheating, high phosphorus "ghost lines," or other abnormalities.

The microscope will not detect alloyed manganese, silicon, copper, or other constituents existing in solid solution with the base iron.

---

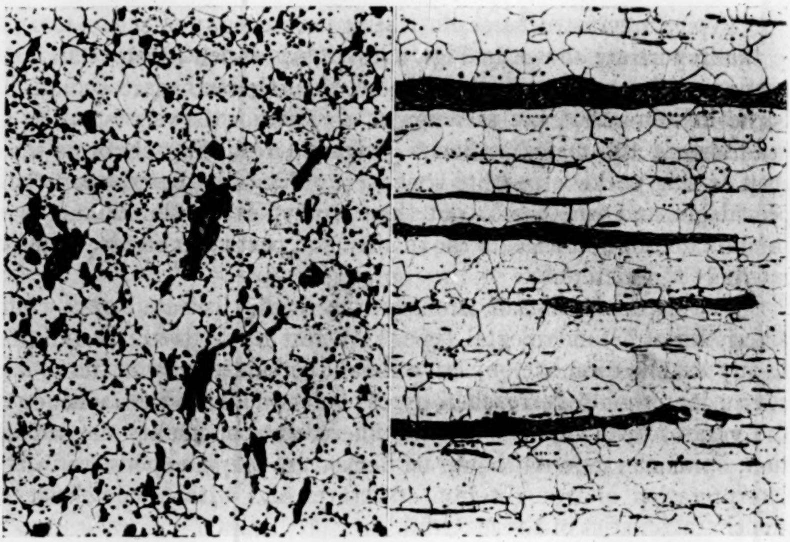
[1] 1933 Book of A.S.T.M. Standards, Part I, pp. 430, 434, 440, 444, 447, 452.

Typical microstructures illustrating the various points enumerated in this report are shown in Figs. 1 to 15, appended hereto. In connection with any examination under the microscope, it should be borne in mind that the area under observation is very small—pin head size at 100 magnification. Judgment regarding abnormalities, such as slag pockets, pearlite zones, etc., should be based upon their prevalence and whether or not they are typical of the character of product and of influence on the quality and particular service requirements of the material.

The determination of wrought iron quality is based upon characteristics of a fundamental type. All test methods are useful, and in any examination the objective should be held clearly in mind, and conclusions should be reached by carefully weighing the evidence of the various tests applied. In the finer points of quality determination, opinions rendered should be backed by ample experience in the interpretation of wrought iron structures and with a knowledge of the characteristics of the material.

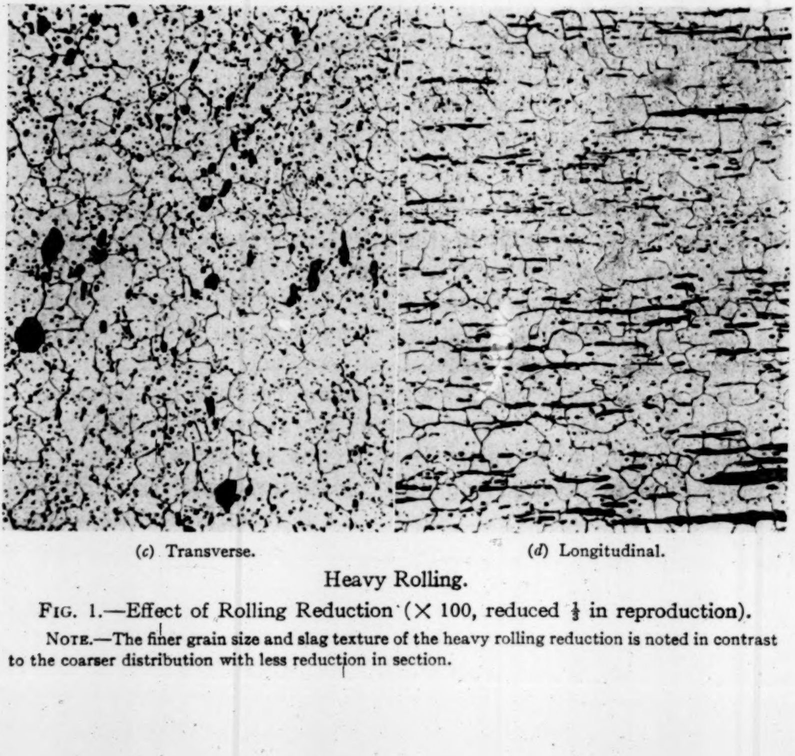
Respectfully submitted,

JAMES ASTON, *chairman*
WILLIAM DOWNS
J. H. HIGGINS
G. E. F. LUNDELL
F. B. OLCOTT
C. T. RESSLER
J. B. SCHLOSSBERG
E. B. STORY
For Subcommittee X on Research



(*a*) Transverse. (*b*) Longitudinal.

Light Rolling.

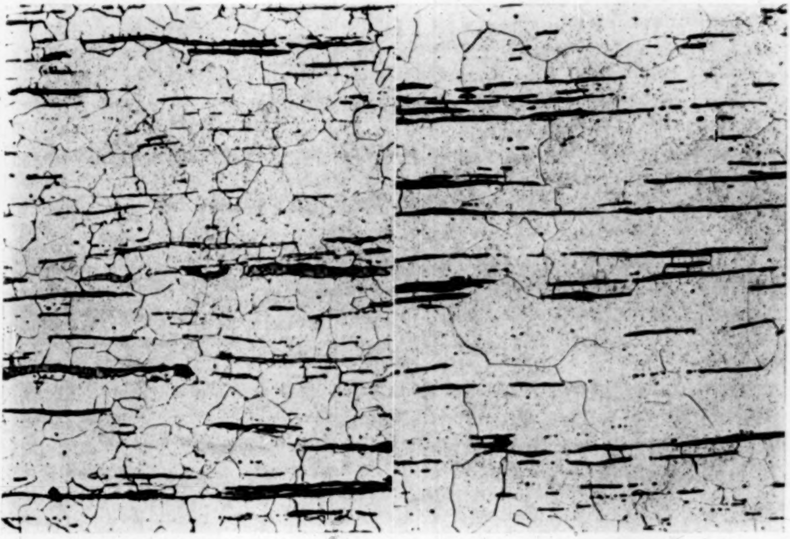


(*c*) Transverse. (*d*) Longitudinal.

Heavy Rolling.

FIG. 1.—Effect of Rolling Reduction (× 100, reduced ⅓ in reproduction).

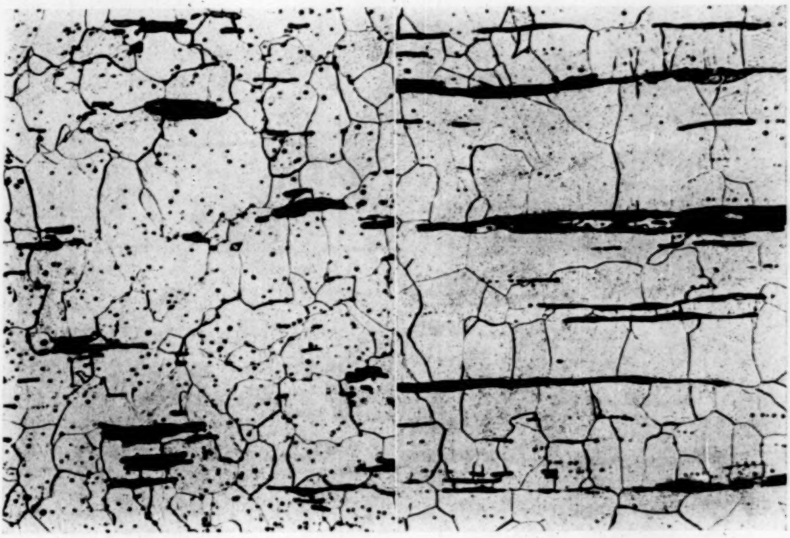
NOTE.—The finer grain size and slag texture of the heavy rolling reduction is noted in contrast to the coarser distribution with less reduction in section.



(*a*) Longitudinal. (*b*) Longitudinal.

FIG. 2.—Finished Bar Iron Sections (× 100, reduced ⅓ in reproduction).

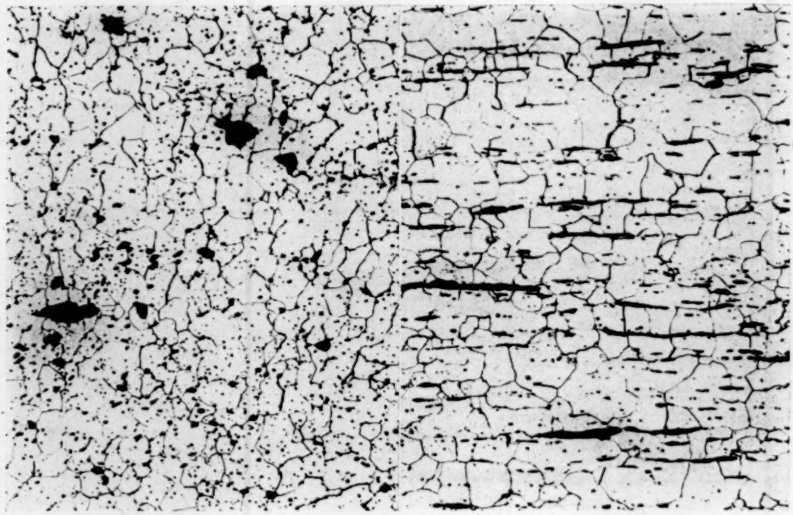
NOTE.—Slag distribution and grain size quite typical of wrought iron of good reduction corresponding to "single worked" bar iron.



(*a*) Transverse. (*b*) Longitudinal.

FIG. 3.—Wrought-Iron Pipe (× 100, reduced ⅓ in reproduction).

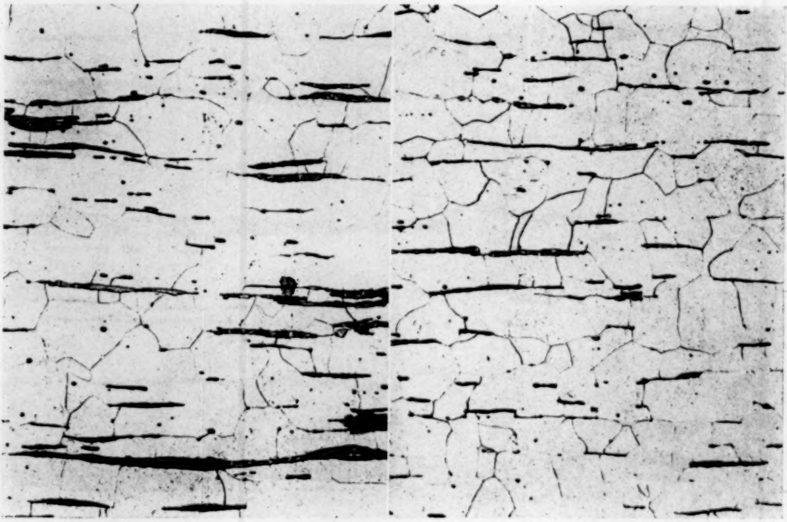
NOTE.—Wrought-iron pipe is equivalent to "single worked" iron and may show somewhat coarser grain size than in bar iron because of high heat of welding with no after rolling reduction.



(a) Transverse. (b) Longitudinal.

FIG. 4.—Staybolt Iron (× 100, reduced $\frac{1}{3}$ in reproduction).

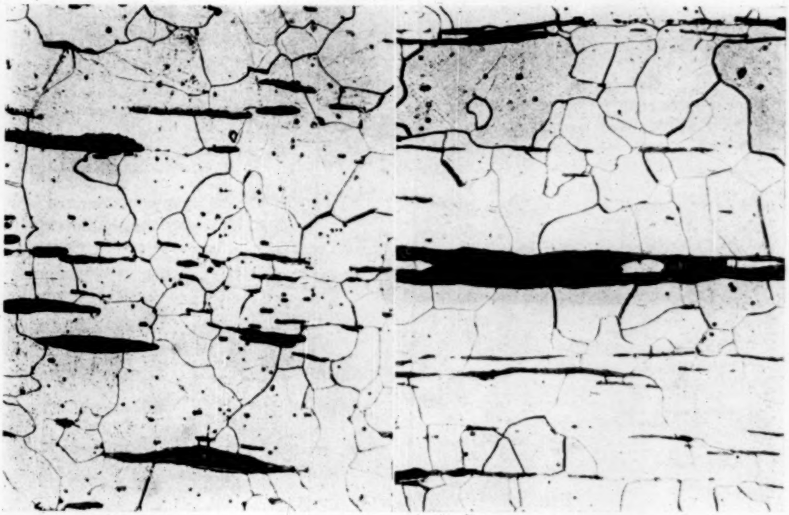
NOTE.—Staybolt iron is commonly made by double working and the photomicrographs show this effect in the fine slag distribution and smaller grain size.



(a) Transverse to Final Rolling Axis. (b) Parallel to Final Rolling Axis.

FIG. 5.—High Transverse Ductility Plate of Flanging Quality (× 100, reduced $\frac{1}{3}$ in reproduction).

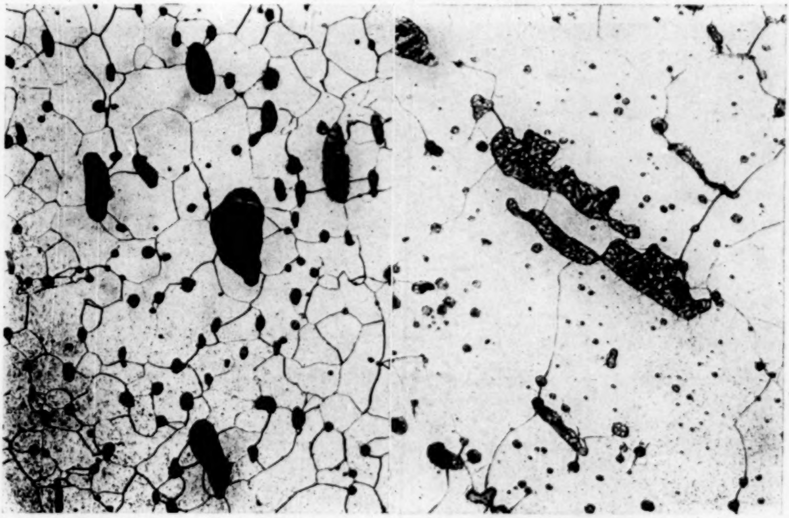
NOTE.—The effect of direction of rolling is indicated on the two photomicrographs which show fairly equal slag elongation in both directions.



(a) Transverse. (b) Longitudinal.

FIG. 6.—Heavy Plate (× 100, reduced ⅓ in reproduction).

NOTE.—The coarse slag distribution and grain size are characteristic of a heavy plate section.



(a) Light Section, Transverse. (b) Heavy Section, Transverse.

FIG. 7.—Forging Billets (× 100, reduced ⅓ in reproduction).

NOTE.—The heavy section has had less reduction in rolling and shows a coarser grain and slag structure than that of the lighter billet.

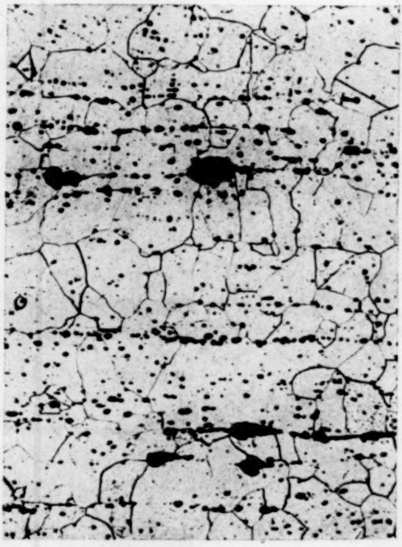


FIG. 8.—Wrought-Iron Sheets (× 100, reduced $\frac{1}{3}$ in reproduction).

NOTE.—The practice of rolling sheets at low temperatures results in a breaking up of the slag filaments. The distribution and character of the slag is practically the same in the longitudinal and transverse directions.

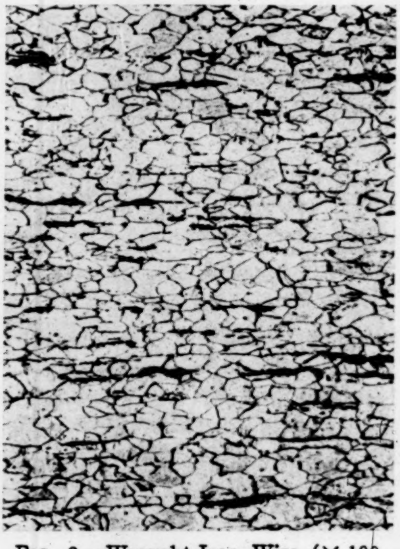
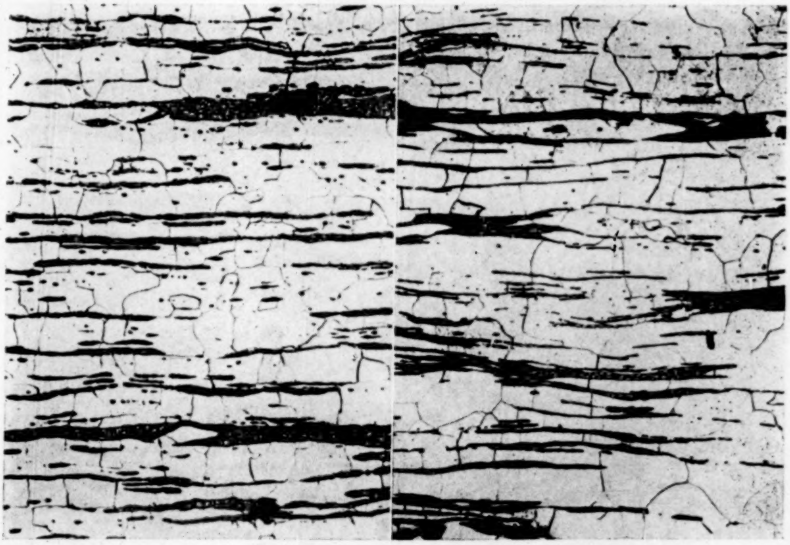


FIG. 9.—Wrought-Iron Wire (× 100, reduced $\frac{1}{3}$ in reproduction).

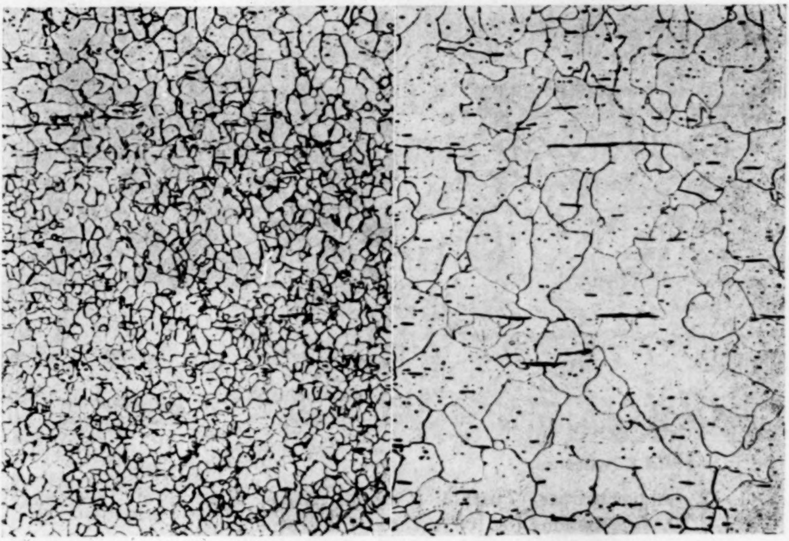
NOTE.—The effect of cold drawing is indicated in the distortion of the grains in the wire sample.



(*a*) Longitudinal. (*b*) Longitudinal.

FIG. 10.—Abnormalities, Over Abundant Slag Quantity but Good Distribution (× 100, reduced ⅓ in reproduction).

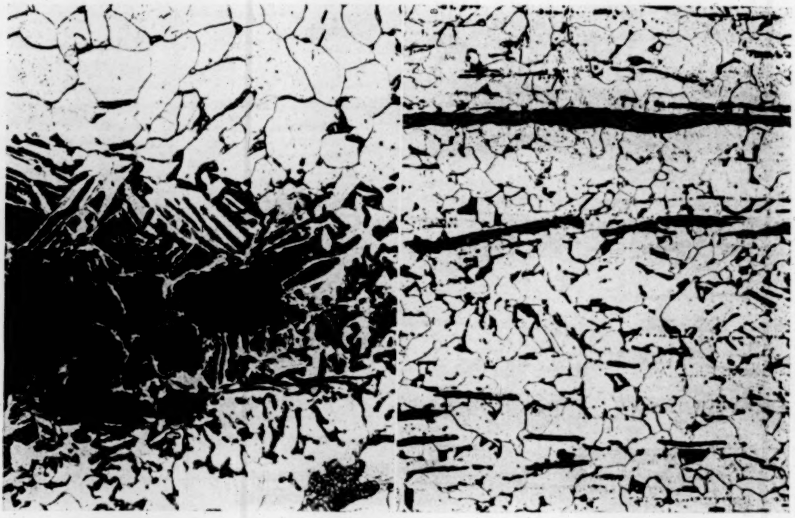
NOTE.—These photomicrographs show excellent refining and good slag character except that the quantity is too great for most products to obtain good physical properties.



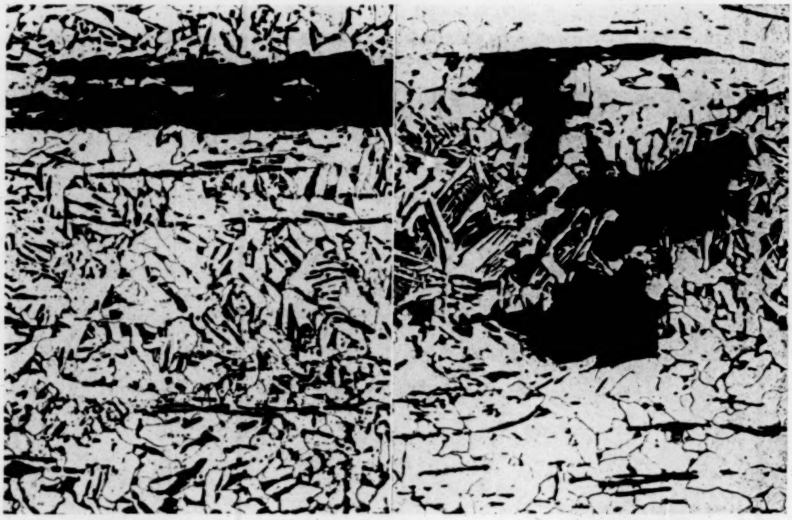
(*a*) Longitudinal. (*b*) Longitudinal.

FIG. 11.—Abnormalities, Deficiency in Slag (× 100, reduced ⅓ in reproduction).

NOTE.—The effects of rolling and finishing temperatures are indicated in the grain size of the two samples. There is an almost complete absence of slag, and the material is abnormal in this respect. It is not necessarily defective unless this deficiency is typical of the entire section.



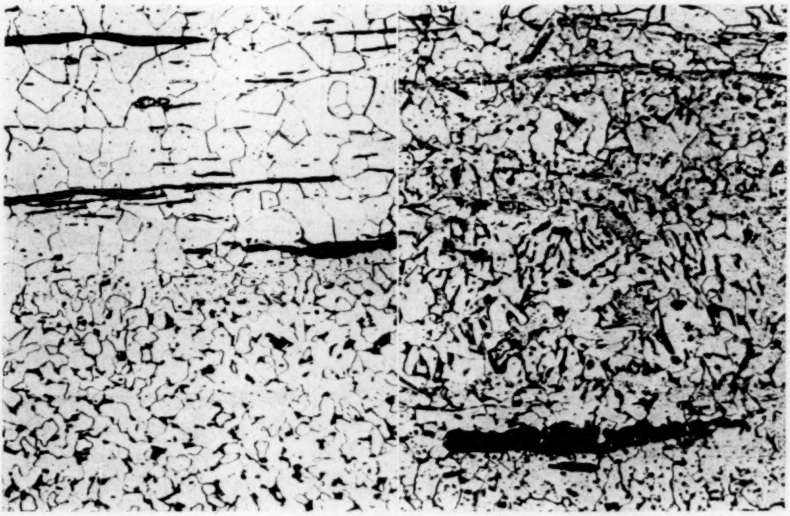
(a) Transverse. (b) Longitudinal.



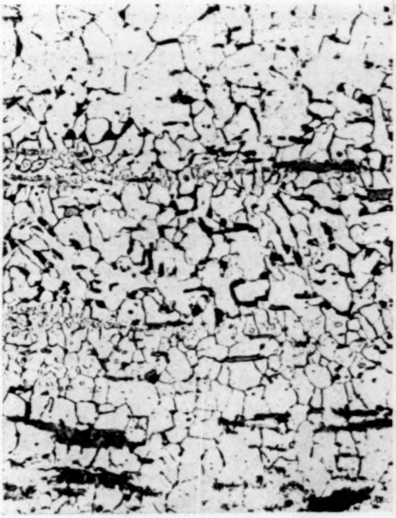
(c) Longitudinal. (d) Longitudinal.

FIG. 12.—Abnormalities, Pearlite (Carbon) Areas, Results of Incomplete Refining (× 100, reduced ⅓ in reproduction).

NOTE.—The photomicrographs show varying amounts of carbon in a spotty distribution. The presence of slag in the carbon areas indicates that the product has not been a result of scrap adulteration. The material can be criticized but its condemnation should rest upon a thorough exploration of the entire section to determine the extent of the abnormality illustrated.



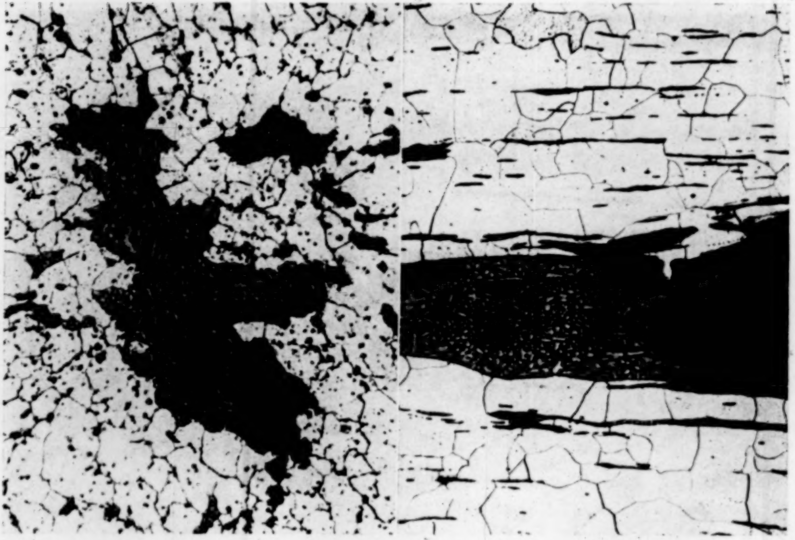
(*a*) Longitudinal. (*b*) Longitudinal.



(*c*) Longitudinal.

FIG. 13.—Abnormalities, Pearlite (Carbon) Areas, Result of Steel Scrap Adulteration (× 100, reduced ⅓ in reproduction).

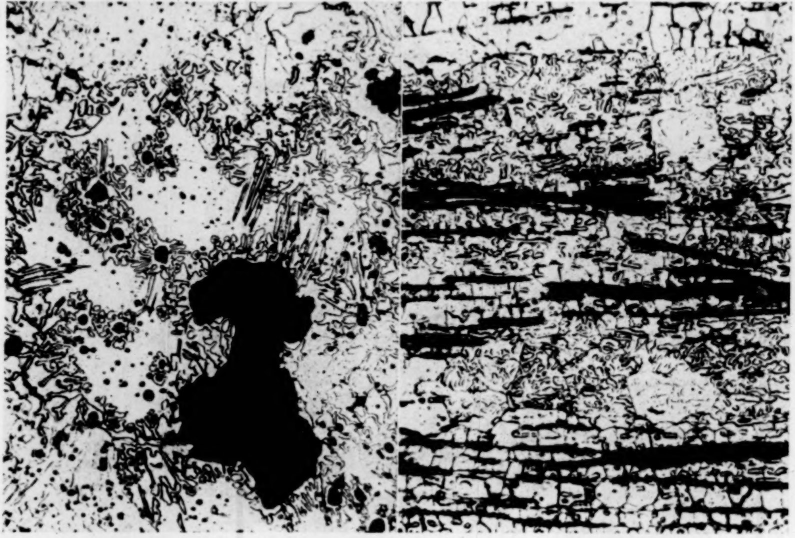
NOTE.—The banded nature of the carbon-bearing zones, with an absence of slag in these zones, and the relatively good wrought-iron structure shown in adjoining bands, is indicative of scrap adulteration in busheling or piling.



(a) Transverse. (b) Longitudinal.

FIG. 14.—Abnormalities, Large Slag Areas (× 100, reduced $\frac{1}{3}$ in reproduction).

NOTE.—Coarse slag areas are likely to result in poor ductility and strength, in faulty machining quality, and in a liability to tear in bending or other forming operations.



(a) Transverse. (b) Longitudinal.

FIG. 15.—Abnormalities, Phosphorus Segregation (× 100, reduced $\frac{1}{3}$ in reproduction).

NOTE.—The segregated or banded nature of the phosphide distribution in the iron matrix is likely to cause a zone of brittleness, especially as a result of high heat influences in welding, etc.

REPORT OF COMMITTEE A-3
ON
CAST IRON

Since the 1933 annual meeting of the Society, Committee A-3 on Cast Iron held one meeting at Washington, D. C., on March 8, 1934. A second meeting will be held prior to the presentation of this report to the Society, at which time the report will be reviewed and other matters will be considered.

A Symposium on Cast Iron was held at a joint meeting of the American Foundrymen's Association and the American Society for Testing Materials at the 1933 annual meeting of the Society at Chicago. After the discussion at this meeting the Symposium was revised for publication in the Proceedings[1] and was also issued as a separate publication in the fall of 1933. This publication has been very well received.

During the past year death has taken from the committee two members who have long been prominently identified with the cast-iron industry: Walter Wood and Stanley G. Flagg, Jr. The passing of these men means a great loss to the committee, to the Society and to the industry.

The present membership of the committee is 94, of whom 33 are classified as producer, 40 as consumer, and 21 as general interest members.

RECOMMENDATIONS AFFECTING STANDARDS

Proposed Revision of Tentative Standard.—The committee recommends certain minor revisions in the Tentative Specifications for Cast-Iron Culvert Pipe (A 142 - 32 T)[2] as proposed by Subcommittee VIII and recommends that the specifications as revised be continued as tentative. This recommendation has been submitted to letter ballot of the committee, which consists of 94 members; 47 members returned their ballots, of whom 44 have voted affirmatively, 0 negatively and 3 members marked their ballots not voting.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 115 (1933).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 619 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 153.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Pig Iron (C. D. Mathews, chairman).—The subcommittee has been asked to make a study of the code governing the pig iron industry and then make recommendations in respect to specifications, etc.

Special Subcommittee on Test Bars (R. S. MacPherran, chairman).—At the June, 1933, meeting a special subcommittee was appointed to study test bars and data in connection with the Tentative Specifications for Gray-Iron Castings (A 48 – 32 T) and make recommendations in respect to these specifications. The report of the subcommittee is appended hereto.

Subcommittee VI on General Castings (J. W. Bolton, chairman).—This subcommittee is waiting for a report from the Special Subcommittee on Test Bars before taking action on revision of the Tentative Specifications for Gray-Iron Castings (A 48 – 32 T).

Subcommittee VIII on Cast-Iron Culvert Pipe (E. F. Kelley, chairman).—This subcommittee is recommending the following revisions in the Tentative Specifications for Cast-Iron Culvert Pipe (A 142 – 32 T):[1]

Section 8.—Change to read as follows by the omission of the word in brackets:

> 8. The pipe shall not fail and shall develop no [visible] cracks when tested under the following loads by the three-edge-bearing method.

Section 9.—Designate the present section as Paragraph (*a*) "Smooth Pipe" and add a new paragraph as Paragraph (*b*) "Corrugated or Ribbed Pipe," to read as follows:

> (*b*) *Corrugated or Ribbed Pipe.*—For corrugated or ribbed pipe the requirements for the three-edge-bearing method shall be the same as described in Paragraph (*a*) for smooth pipe. In the case of corrugated pipe, the bearing blocks shall be placed in contact with the outside crests of the corrugations. In the case of ribbed pipe, the bearing blocks shall be placed in contact with the tops of the transverse ribs. If the ribbed pipe has longitudinal ribs, the pipe shall be placed so that the bearing blocks will be, as nearly as possible, midway between the longitudinal ribs.

Section 14.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> 14. Pipe specimens shall be tested under a load 10 per cent in excess of the load specified for the particular class of pipe. Shipments represented by specimens which sustain the specified load without the development of [visible]

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 619 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 153.

cracks shall be accepted *as fulfilling the strength requirements.* Specimens of pipe *which meet all other requirements of the specifications and* which sustain a load 10 per cent in excess of that specified without the development of [visible] cracks shall be accepted *for use.* The cost of specimens which fail to sustain the specified load, or a load 10 per cent in excess of that specified, shall be borne by the manufacturer.

Section 17.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

17. *Unless otherwise specified,* pipe shall have a minimum laying length of 3 ft. [Unless otherwise specified, the maximum laying length shall be 12 ft.]

Subcommittee X on Nomenclature and Definitions (Robert Job, chairman).—A list of definitions has been submitted by the subcommittee for action by Committee A-3.

Subcommittee XV on Impact Testing (J. T. MacKenzie, chairman).—The report of the impact testing investigation has resulted in favorable comment on this exhaustive study. The investigation has shown that the drop test is a valuable test to measure resistance to repeated type of impact. The subcommittee will be enlarged to include those who will cooperate in making these tests. It is hoped that a standard method of test will be developed.

The election of officers for the ensuing term of two years resulted in the selection of Hyman Bornstein, chairman; W. H. Rother, vice-chairman, and E. K. Smith, secretary.

This report has been submitted to letter ballot of the committee, which consists of 94 members; 47 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

HYMAN BORNSTEIN,
Chairman.

W. H. ROTHER,
Secretary.

EDITORIAL NOTE

The revisions of the Tentative Specifications for Cast-Iron Culvert Pipe were accepted. The specifications in their revised form appear on page 654.

REPORT OF SPECIAL SUBCOMMITTEE ON TEST BARS

The Special Subcommittee on Test Bars appointed by Committee A-3 on Cast Iron was requested to secure information as follows:

1. Methods of making test bars.
2. Correlation of test bar sizes and controlling sections as shown in the Tentative Specifications for Gray-Iron Castings (A 48 – 32 T).[1]
3. Determination of deflection values in the transverse tests.
4. Comparison of tensile strength tests on broken halves of transverse test bars and on separately cast tension bars.

Information on the above is necessary in order to provide a check on the provisions of the Tentative Specifications A 48 – 32 T, so that these specifications may be revised and made of greater value.

Some work was done on methods of making test bars, including bars cast horizontally in green sand and on bars cast vertically in dry sand cores. However, a good deal of the work planned was not completed in time for this year's report and, consequently, definite recommendations on the manufacture of test bars cannot be made at this time.

The strength of any iron is affected by the cooling rate. The total weight and the various cross-sections of any casting will affect this cooling rate. For example, a plate or section 1 in. in thickness will cool more slowly in a 10-ton casting than in a 100-lb. casting. This may also be modified by the fact that in a casting with largely a 1-in. section, there may be other sections of much greater thickness which will retard the cooling rate. This fact should be recognized and taken into consideration when translating the strength of a test bar into the strength of a section of a casting.

A test bar cools from all sides, whereas a plate cools from two sides only. Schwartz and Vath[2] report that up to a wall thickness of 30 mm. (1.18 in.) a plate is properly represented by a round test bar whose diameter is equal to twice the thickness of the plate. These results, together with the results of the investigations of this special committee, indicate that it will be necessary to revise the thickness of sections to be represented by test bars, as shown at present in Specifications A 48 – 32 T.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 625 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 145.

[2] *Foundry Trade Journal*, October 12, 1933.

Table I.—Results of Chemical and Physical Tests Made at the University of Illinois on Bars Made in Accordance with A.S.T.M. Tentative Specifications for Gray-Iron Castings (A 48 – 32 T).

Test Bar	Transverse Strength, lb.			Tensile Strength, lb. per sq. in.		
	Bar A, 0.875-in. Diam., Tested on 12-in. Span	Bar B, 1.20-in. Diam., Tested on 18-in. Span	Bar C, 2.00-in. Diam., Tested on 24-in. Span	Bar A, 0.505-in. Diam. Bar[a]	Bar B, 0.8-in. Diam. Bar[a]	Bar C, 1.25-in. Diam. Bar[a]
No. 16	1510	2660	8 325	45 500	......	31 490
No. 16	1660	2540	8 840	44 550	......	32 275
No. 17	1310	2430	7 750	44 200	......	27 745
No. 17	1455	2320	6 220[b]	44 300	......	27 680
No. 18	1520	2210	8 455	40 750	36 760	......
No. 18	1455	2130	8 380	39 450	37 620	30 930
No. 18NC	1735	2645[b]	8 600	49 200	......	39 715
No. 18NC	1865	2910	9 000	49 500	45 160	38 445
No. 19	1440	2525	7 750	39 650	......	28 370
No. 19	1440	2450	7 120	39 800	35 700	27 710
No. 23	1995	3155	10 180	61 900	55 800	42 760
No. 23	2070	3330	10 640	61 100	......	43 610

Chemical Analyses

Marking	Total Carbon, per cent	Silicon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Nickel, per cent	Chromium, per cent
16	3.19	2.44	0.77	0.220	0.136	0.38	0.77
17	3.40	2.41	0.76	0.193	0.140	0.31	1.26
18	3.16	2.27	0.72	0.158	0.151	0.55	0.11
19	3.22	2.65	0.70	0.183	0.132	0.39	0.05
18NC	3.15	2.19	0.70	0.171	0.124	1.90	0.58
23	3.07	1.89	0.52	0.079	0.117	2.21	0.34

[a] Tension tests were made on broken halves of the transverse test bars.
[b] Flaw.

Table II.—Results of Tests Made at the University of Illinois on Bars Made in Accordance with A.S.T.M. Tentative Specifications for Gray-Iron Castings (A 48 – 32 T).

Foundry	Test Bar	Transverse Strength, lb.			Tensile Strength, lb. per sq. in.		
		Bar A, 0.875-in. Diam., Tested on 12-in. Span	Bar B, 1.20-in. Diam., Tested on 18-in. Span	Bar C, 2.00-in. Diam., Tested on 24-in. Span	Bar A, 0.505-in. Diam. Bar[a]	Bar B, 0.8-in. Diam. Bar[a]	Bar C, 1.25-in. Diam. Bar[a]
No. 1	No. 1	1620	2260	8270	[b]	42 140	40 620
	No. 2	1610	2540	7635	[b]	......	40 490
	No. 3	1590	2355	8225	[b]	44 160	39 120
No. 2	....	1135	1800	5285	30 600	25 400	24 000
	....	1080	2150	5190	30 800	27 480	23 843
	....	1190	1910	4895	30 800	24 040	23 950
	....	1120	1880	5130	31 750	25 500	23 980
	....	1150	1830	4825	31 200	27 820	24 290
No. 3	No. 1	940	1570	5020	27 000	20 560	15 640
	No. 2	1175	1750	5345	27 150	19 860	15 715
	No. 3	1275	1795	5390	19 050[c]	20 000	15 650

[a] Tension tests were made on broken halves of the transverse test bars.
[b] Too hard to machine.
[c] Defect.

Tests at University of Illinois:

A number of transverse and tension tests were made at the University of Illinois on irons cast into the three sizes of transverse bars. The tension tests were made on the broken halves of transverse test bars. Results of tests and chemical analyses are shown in Tables I and II. It will be noted that deflection values in the transverse test are not shown.

TABLE III.—RESULTS OF CHEMICAL AND PHYSICAL TESTS ON BARS MADE IN ACCORDANCE WITH A.S.T.M. TENTATIVE SPECIFICATIONS FOR GRAY-IRON CASTINGS (A 48 – 32 T), CAST AND TESTED BY THE ALLIS-CHALMERS MANUFACTURING CO.

Designation	Transverse Strength						Tensile Strength of Broken Halves of Transverse Bars, lb. per sq. in.			Tensile Strength of Separately Cast Bars, lb. per sq. in.	
	Bar A, 0.875-in. Diam., Tested on 12-in. Span		Bar B, 1.20-in. Diam., Tested on 18-in. Span		Bar C, 2.00-in. Diam., Tested on 24-in. Span						
	Load, lb.	Deflection, in.	Load, lb.	Deflection, in.	Load, lb.	Deflection, in.	Bar A, 0.505-in. Diam.	Bar B, 0.800-in. Diam.	Bar C, 1.25-in. Diam.	Bar B, 1.10-in. Diam.	Bar C, 1.80-in. Diam.
No. 1—Iron A	1690	0.15	2610	0.31	8510	0.42	44 200	40 100	30 300	......	......
	1540	0.15	2410	0.25	8330	0.36	43 700	40 700	29 700	......	......
	1650	0.18	2450	0.27	....	....	......	......	......	......	......
No. 2—Iron HT	1840	0.16	3125	0.26	11090	0.31	62 200	62 600	53 200	......	......
	1910	0.15	3220	0.27	10760	0.29	69 300	55 200	53 700	......	......
No. 3—Iron B	1380	0.18	2185	0.29	7040	0.35	38 800	31 800	24 150	28 600	25 270
	1385	0.18	2275	0.30	7450	0.39	38 400	31 400	25 320	29 100	25 860
No. 4—Iron C	1290	0.17	1940	0.29	4950	0.26	30 200	24 300	17 600	21 900	17 290
	1265	0.16	1870	0.27	5640	0.33	29 700	22 400	16 600	22 100	17 310
No. 5—Iron A	1710	0.13	2620	0.27	8230	0.26	Too Hard	36 700	30 330	34 300	31 450
	1840	0.15	2600	0.27	8190	0.32		34 500	31 000	34 070	30 700
	1750	0.15	2650	0.27	8500	0.39	......	......	......	......	......

CHEMICAL ANALYSES

Designation	Total Carbon, per cent	Silicon, per cent	Sulfur, per cent	Phosphorus, per cent	Manganese, per cent	Nickel, per cent
No. 1—Iron A	3.40	1.15	0.091	0.21	0.77	....
No. 2—Iron HT	2.82	2.06	0.100	0.10	0.74	0.91
No. 3—Iron B	3.53	1.69	0.091	0.24	0.59	....
No. 4—Iron C	3.58	2.23	0.083	0.46	0.58	....
No. 5—Iron A	3.34	1.13	0.093	0.17	0.61	....

Tests at Allis-Chalmers Manufacturing Co.:

A number of irons were cast into three sizes of bars by the Allis-Chalmers Manufacturing Co. Transverse tests were made on the three sizes of bars, also tension tests on the broken halves of the transverse bars. Furthermore, separately cast tension test bars were made, machined and tested. The results, including the chemical analyses, are shown in Table III.

It is important to note that good results were obtained on the tension test bars prepared from the transverse bars as compared with the separately cast tension bars.

Tests at University of Michigan:

Test bars were made up in the various sizes, including transverse bars and separately cast tension bars. Tensile strength tests were made at the University of Michigan on the broken halves of the transverse bars and on the separately cast tension bars. Five sets of bars were tested and results are shown in Table IV.

TABLE IV.—RESULTS OF TESTS MADE AT THE UNIVERSITY OF MICHIGAN ON BARS MADE IN ACCORDANCE WITH A.S.T.M. TENTATIVE SPECIFICATIONS FOR GRAY-IRON CASTINGS (A 48 – 32 T).

NOTES.—All bars were cast vertically in dry-sand cores.
Test Bar U was cast to size and shape.
Corrections were made for size of cast bars in transverse tests.
All tension test specimens were accurately machined with polished finish.
All tension tests were made in self-aligning holders.
With few exceptions, each value in the table is the average of four tests of different bars.

Heat	Transverse Strength						Tensile Strength of Broken Halves of Transverse Bars, lb. per sq. in.			Tensile Strength of Separately Cast Bars, lb. per sq. in.		
	Bar A, 0.875-in. Diam., Tested on 12-in. Span		Bar B, 1.20-in. Diam., Tested on 18-in. Span		Bar C, 2.00-in. Diam., Tested on 24-in. Span							
	Load, lb.	Deflection, in.	Load, lb.	Deflection, in.	Load, lb.	Deflection, in.	Bar A, 0.505-in. Diam.	Bar B, 0.800-in. Diam.	Bar C, 1.25-in. Diam.	Bar A, 0.800-in. Diam.	Bar B, 1.10-in. Diam.	Bar U, 0.800-in. Diam.
No. 1[a]......	933	0.15	1600	0.23	3 930	0.25	26 050	21 540	14 860[f]	22 920	21 028	17 908
No. 2[b]......	1791	0.15	2553	0.27	8 113	0.34	54 100	45 440	37 760[f]	48 790	41 580	41 340
No. 3[c]......	1101	0.14	1707	0.22	4 825	0.30	24 730	22 790	17 150[f]	23 840	20 740	23 995
No. 5[d]......	1109	0.13	1754	0.22	4 185	0.24	27 600	20 230	13 330[f]	25 690	21 020	25 245
No. 7[e]......	1812	0.20	2800	0.29	10 000	0.39	54 400	43 540	......	46 130	44 370	45 280

[a] Plain gray iron.
[b] Steel mixture without alloy.
[c] Plain gray iron.
[d] Plain gray iron.
[e] Steel mixture with 1.5 per cent nickel. All cupola iron.
[f] Average tensile strength.

It will be noted that tension tests on the bars prepared from the broken halves of transverse bars compare favorably with tests on the separately cast tension bars. The methods of making the bars are noted in Table IV.

Tests at University of Wisconsin:

The University of Wisconsin received CWA funds (Project E 18–17) to carry on tests on cast-iron test bars. Deere and Co., Moline, Ill., and Frank Foundries Corp., Moline, Ill., furnished three sets and two sets of bars, respectively. Each set of bars consisted of bar A, B, and C in both transverse and separately cast tension bars. Each set was furnished in duplicate.

The university was supposed to make transverse tests and tension tests on both the broken transverse bars and separately cast tension bars. The transverse bars were cast in green sand according to method shown in Fig. 4 of the Tentative Specifications A 48 - 32 T.[1] The tension bars were cast vertically in dry sand cores.

Up to the present, the University of Wisconsin has reported only the results of transverse tests and these are shown in Table V. The completion of tension tests on these bars will furnish valuable information.

TABLE V.—RESULTS OF TESTS AT UNIVERSITY OF WISCONSIN ON BARS MADE BY COMMERCIAL FOUNDRIES IN ACCORDANCE WITH A.S.T.M. TENTATIVE SPECIFICATIONS FOR GRAY-IRON CASTINGS (A 48 - 32 T).

TRANSVERSE STRENGTH AND DEFLECTION

Lot	Bar A, 0.875-in. Diam., Tested on 12-in. Span		Bar B, 1.20-in. Diam., Tested on 18-in. Span		Bar C, 2.00-in. Diam., Tested on 24-in. Span	
	Load, lb.	Deflection, in.	Load, lb.	Deflection, in.	Load, lb.	Deflection, in.
No. 4	1910	0.17	2500	0.33	7 540	0.32
	1822	0.17	2488	0.33	7 587	0.33
No. 5	2439	0.13	3218	0.28	13 430	0.39
	2785	0.15	3360	0.28	11 150	0.32
No. 6	1700	0.18	1932	0.32	6 255	0.37
	....	....	1957	0.33	6 312	0.36
No. 7	1739	0.15	2550	0.27	7 648	0.30
	1876	0.18	2795	0.30	8 197	0.30
No. 8	2079[a]	0.10[a]	2723	0.21	9 850	0.23
	2100[a]	0.10[a]	2839	0.22	9 350	0.22

CHEMICAL ANALYSES FURNISHED BY MANUFACTURERS[b]

Lot	Total Carbon, per cent	Graphite, per cent	Combined Carbon, per cent	Silicon, per cent	Sulfur, per cent	Phosphorus, per cent	Manganese, per cent	Nickel, per cent	Chromium, per cent
No. 4	3.30	....	0.51	2.43	0.135	0.52	0.75	....	....
No. 5	2.49	....	....	1.86	0.060	0.16	0.66	....	....
No. 6	3.46	....	....	2.17	0.110	0.47	0.49	....	....
No. 7	3.33	2.64	0.69	2.08	0.075	0.195	0.66	1.36	0.71
No. 8	2.54	1.72	0.82	2.08	0.104	0.156	0.60	....	....

[a] The 0.875-in. bars of Lot No. 8 were mottled.

[b] Lots Nos. 4, 5 and 6 were furnished by Deere and Co., and Lots Nos. 7 and 8 by Frank Foundries Corp. The chemical analyses of Lots No. 7 and 8 were made on drillings from the riser on the 1.20-in. bars.

Correlation of Test Bars and Castings at Allis-Chalmers Mfg. Co.:

The Allis-Chalmers Manufacturing Co. has made tests comparing results obtained on the old arbitration bar (1.25 in. in diameter) with those obtained on bars cut from a 3-in. wall in the exhaust port of a 60-in. diameter cylinder. The results are shown in Table VI.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 631 (1932); also 1933 Book of A.S.T.M Tentative Standards, p. 151.

Acknowledgment:

The special subcommittee wishes to acknowledge the assistance of the following in carrying on its program:

University of Illinois, Urbana, Ill.
University of Michigan, Ann Arbor, Mich.
Deere and Co., Moline, Ill.
Frank Foundries Corp., Moline, Ill.
Allis-Chalmers Manufacturing Co., Milwaukee, Wis.
Lunkenheimer Co., Cincinnati, Ohio.
Nordberg Manufacturing Co., Milwaukee, Wis.
Caterpillar Tractor Co., Peoria, Ill.

TABLE VI.—RESULTS OF CHEMICAL ANALYSIS AND PHYSICAL TESTS MADE BY ALLIS-CHALMERS MANUFACTURING CO. ON ARBITRATION TEST BAR AND BARS FROM 60-IN. CYLINDERS.

NOTE.—Cylinder wall thickness in bore, 4 in.; outer wall thickness, 3½ in.; weight of casting in rough, 45 tons.

	Transverse Strength of Old Arbitration Test Bar[a]		Tensile Strength, lb. per sq. in.	
	Load, lb.	Deflection, in.	Bar Cut from Broken Half of Transverse Bar	Bar Cut from 3-in. Wall in Exhaust Port of 60-in. Cylinder
No. 1	4500	0.16	44 900	31 300
No. 2	4060	0.17	41 000	28 300
	4190	0.15	......	28 200
No. 3	4870	0.17	42 200	31 400
	4270	0.15	43 400	29 100
No. 4	4180	0.13	43 600	31 300
	....	0.13	......	31 300
No. 5	4770	0.15	44 000	33 000
	4580	0.14	44 100	34 500
No. 6	3930	0.13	......	23 100
	....	....	......	23 300

CHEMICAL ANALYSES

	Total Carbon, per cent	Silicon, per cent	Sulfur, per cent	Manganese, per cent	Chromium, per cent	Nickel, per cent
No. 1	3.10	1.26	0.097	0.86	0.19	0.55
No. 2	3.26	1.26	0.087	0.83	0.08	....
No. 3	3.25	1.06	0.090	0.81	0.09	....
No. 4	3.19	1.40	0.084	0.65	0.33	0.60
No. 5	3.16	1.33	0.103	0.67	0.19	0.32
No. 6	3.26	1.36	0.088	0.72	....	....

[a] Old arbitration test bar was 1.25 in. in diameter and 15 in. in length and was tested on 12-in. span.

Further work is in progress by several investigators and the subcommittee hopes to be able to make definite recommendations within the next year.

Respectfully submitted on behalf of the special subcommittee,

R. S. MACPHERRAN,
Chairman.

REPORT OF COMMITTEE A-5

ON

CORROSION OF IRON AND STEEL

Committee A-5 on Corrosion of Iron and Steel has held two meetings during the past year, one at Chicago, Ill., during the 1933 annual meeting of the Society and the other at Washington, D. C., in March, 1934, at the time of the Spring Group Meeting of A.S.T.M. Committees. The activities of the committee have been centered on the corrosion test programs, investigations and projects now under way and which are carried on under the guidance of the various subcommittees. This work is progressing satisfactorily as recorded later in this report under the activities of the subcommittees.

This year Committee A-5 mourns the loss of its beloved chairman, James H. Gibboney, who died during October after a short illness. At its meeting in March the committee adopted the following resolutions:

RESOLVED, That Committee A-5, whose destiny was directed from 1922 to the end of 1933 by the late James H. Gibboney, desires to record its untold loss in his passing.

Committee A-5 presented to its chairman for prompt and satisfactory dispatch miscellaneous problems which represented the considered opinion of members or groups of members who are likely to be affected in a far-reaching way by his action and decision. Only a friend whose comprehension passed all understanding or a person in whom one had the utmost confidence could have carried on so successfully in the position. Such an outstanding individual was our late chairman. Therefore, be it further

RESOLVED, That this appreciation be spread upon the minutes of this committee for presentation in its report to the Society; and be it also further

RESOLVED, That a copy of this resolution be transmitted to Mrs. James H. Gibboney and her children whose loss we share.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee III on Inspection of Annapolis Tests.—During the past year two inspections have been made of the Nos. 16 and 22 gage uncoated sheets which have been exposed at Annapolis, Md., since October, 1916. At the inspection on October 27, 1933, after 17 years exposure, failures were observed in two sheets in the copper-bearing group and in six non-copper-bearing sheets. At the inspection on April 26, 1934, after an exposure of 17 years, 6 months, failures were observed in one copper-bearing sheet and in three sheets in the non-copper-bearing group. These failures were all of the No. 22 gage sheets and have been listed in Table I (Plate I) which shows the complete record of failures observed at all inspections since the tests were undertaken. None of the No. 16 gage sheets have failed. The tests are being continued.

Subcommittee V on Total Immersion Tests (F. B. Olcott, chairman).—This subcommittee has continued the periodic inspections of the numerous total immersion tests which are in progress. The details are shown in the appended report. These tests will eventually yield important results but have not yet progressed sufficiently to warrant drawing definite conclusions.

Subcommittee VI on Specifications for Metallic-Coated Products (F. F. Farnsworth, chairman).—The appended report of this subcommittee does not indicate the real importance of the work accomplished during the past year in arousing the interest of consumers in a quality product for farm fencing. Representatives of agricultural associations have attended meetings, which the chairman of the subcommittee has arranged for discussion of this special topic, and have expressed a lively appreciation of the subject. In the near future this interest, also fostered by the progress of the field tests to be started soon, should result in important improvements in the specifications for these materials.

Subcommittee VII on Methods of Testing (E. S. Taylerson, chairman).—A special group of this subcommittee is developing methods for determining the weights of electrodeposited coatings for which there is an earnest demand. Consideration is also being given to tests of coatings other than zinc and tin, and deposited by means other than electricity.

Subcommittee VIII on Field Tests of Metallic Coatings (R. F. Passano, chairman).—Subcommittee VIII continued during the year the periodic inspections of the galvanized sheet specimens that have now been exposed at the various test locations for more than 7 yr. In its report, appended hereto, the subcommittee records the results of these inspections and presents an interesting summary of the first failures at the Altoona, Pa., test location where all the galvanized sheet specimens have now rusted. Tables of data have been included showing the progressive development of rust on the exposed surface of galvanized sheets, by coating classes, at the test locations at Altoona, Pa.; Brunot Island, Pa.; and Sandy Hook, N. J.

Further inspections of the tests on coated hardware, structural shapes, tubular goods, etc., have been made. It will be recalled that the 1933 report[1] contained a detailed tabulation of the inspections of these tests after an exposure period of 206 weeks. The appended report includes a brief summary of the progress that has been made in the investigation of electrodeposited coatings carried on by a Joint Inspection Committee and in which Subcommittee VIII has cooperated to a limited extent.

The Wire Test Committee of Subcommittee VIII has completed a major portion of the planning work required before the actual outdoor testing of galvanized wire and wire products can be satisfactorily undertaken. Consideration is now being given to the procurement of samples, determination of their physical properties, and the erection of test racks and exposure of samples, looking toward the actual exposure of the tests in the spring of 1935.

To insure careful planning of the tests and in order to increase the usefulness of test data which will be obtained from these studies, the Wire Test Committee has enlisted the aid of technical representatives of the farming interests, such as the American Society of Agricultural Engineers, American Farm Bureau Federation, and Agricultural Experiment Stations. These agencies have contributed greatly to the work, both by way of technical advice and by making available test sites for exposure racks, and by their assistance in inspections and the interpretation of test data which will be obtained.

Subcommittee X on Embrittlement Investigation (W. G. Kelley, chairman).—Subcommittee X has in hand some supplementary work, following its main report in 1932, on the embrittlement of galvanized structural steel. The details are shown in the appended report of the subcommittee indicating that reliable data can be but slowly acquired.

The election of officers resulted in the selection of F. F. Farnsworth, chairman, H. E. Smith and F. N. Speller, vice-chairmen, and James Aston, secretary, for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 127 members; 60 members returned their ballots, of whom 58 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

H. E. SMITH,
Acting Chairman.

JAMES ASTON,
Secretary.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 156 (1933).

TABLE I.—FAILURES AT ANNAPOLIS TESTS. INSPECTIONS OF 1917, 1918, 1919,
Co

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test				
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Mar. 5, 1923.[a] 77 Months	Oct. 10, 1923. 84 Months	Apr. 18, 1924. 90 Months	Oct. 96 M
EE	Puddled Iron	A	Copper-Bearing	0.035	0.03	0.119	0.018	0.125	0.319	12	None	None	None	N
HH	Copper-Bearing Basic Open-hearth Steel	A	" "	0.074	0.373	0.011	0.026	0.004	0.237	16	None	None	None	N
II	Copper-Bearing Bessemer Steel	A	" "	0.059	0.371	0.095	0.066	0.006	0.247	16	None	None	None	N
KK	Copper-Bearing Acid Open-hearth Steel	A	" "	0.108	0.433	0.085	0.043	0.005	0.234	18	None	None	None	N
CCC	Copper-Bearing Pure Iron	A	" "	0.023	0.026	0.005	0.028	0.005	0.236	12	None	None	None	N
TT	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.080	0.313	0.009	0.020	0.006	0.223	14	None	None	None	N
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.018	0.066	0.008	0.028	0.005	0.239	14	None	None	None	N
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.018	0.046	0.007	0.019	0.004	0.299	14	None	None	None	N
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.113	0.413	0.109	0.045	.....	0.167	2	None	None	None	No
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.080	0.34	0.091	0.036	.....	0.293	3	None	None	None	No
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.073	0.305	0.089	0.045	None	0.532	2	None	None	None	No
ZZ	Copper Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.074	0.39	0.069	0.072	....	0.255	3	None	None	None	No
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.077	0.363	0.057	0.080	0.002	0.652	2	None	None	None	No
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.42	0.050	0.048	Trace	0.363	2	None	None	None	No
	Total	.....	.....	.....	.....	.....	.....	.....	.....	130	None	None	None	No
AA	Bessemer Steel	A	Non-Copper-Bearing	0.043	0.419	0.083	0.042	0.004	0.012	18	None	None	None	No
BB	Open-hearth Steel	A	" " "	0.056	0.349	0.022	0.048	0.037	0.113	17	None	None	None	No
CC	Copper-Bearing Pure Iron	A	" " "	0.019	0.029	0.004	0.032	0.003	0.067	12	None	None	None	No
DD	Low-Copper Pure Iron	A	" " "	0.019	0.028	0.004	0.027	0.004	0.028	19	None	None	None	No
OO	Low-Copper Open-hearth Steel	A	" " "	0.108	0.371	0.009	0.029	0.007	0.029	12	None	None	None	No
MM	Open-hearth Steel, Alan Wood Steel Co.	B	" " "	0.017	0.414	0.010	0.029	0.007	0.057	14	None	None	None	No
SS	Low-Copper Pure Iron, American Rolling Mill Co.	B	" " "	0.017	0.021	0.006	0.021	0.006	0.025	14	None	None	None	No
XX	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.062	0.008	0.030	0.005	0.028	14	None	None	None	No
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.051	0.123	0.019	0.203	0.023	3	None	None	None	No
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.08	0.43	0.080	0.031	0.008	0.014	3	None	None	None	No
ZZ	Open-hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.047	0.389	0.040	0.027	0.007	0.033	3	None	None	None	No
	Total	.....	.....	.....	.....	.....	.....	.....	.....	129	None	None	None	No
B	Open-hearth Steel	A	Copper-Bearing	0.06	0.27	0.014	0.053	0.006	0.187	9	None	None	None	No
C	Copper Bearing Pure Iron	A	" "	0.015	0.028	0.006	0.036	0.003	0.194	9	None	None	None	No
E	Puddled Iron	A	" "	0.033	0.034	0.114	0.021	0.134	0.283	11	None	None	None	No
H	Copper-Bearing Basic Open-hearth Steel	A	" "	0.069	0.387	0.016	0.027	0.004	0.244	16	None	None	None	No
I	Copper-Bearing Bessemer Steel	A	" "	0.041	0.365	0.097	0.068	0.008	0.252	16	None	None	None	No
K	Copper-Bearing Acid Open-hearth Steel	A	" "	0.107	0.447	0.091	0.046	0.004	0.237	16	None	None	None	No
M	Open-hearth Steel, Alan Wood Steel Co	B	" "	0.093	0.419	0.013	0.041	0.011	0.185	14	None	None	None	No
T	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.083	0.313	0.009	0.020	0.005	0.227	14	None	None	None	No
U	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.017	0.074	0.008	0.037	0.005	0.260	14	None	None	None	No
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.018	0.051	0.007	0.021	0.005	0.304	14	None	None	None	No
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.058	0.37	0.093	0.043	0.009	0.269	3	None	None	None	No
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.055	0.38	0.110	0.046		0.527	3	None	None	None	No
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.067	0.351	0.045	0.052	0.003	0.187	3	None	None	None	No
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.065	0.35	0.050	0.059	0.003	0.264	3	None	None	None	No
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.073	0.42	0.052	0.054	Trace	0.641	3	None	None	None	No
	Total	.....	.....	.....	.....	.....	.....	.....	.....	148	None	None	None	Nor
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.386	0.089	0.040	0.007	0.014	14	None	None	None	Nor
B	Open-hearth Steel	A	" " "	0.09	0.38	0.017	0.062	0.036	0.084	3	None	None	None	Nor
C	Copper-Bearing Pure Iron	A	" " "	0.01	0.028	0.002	0.027	0.002	0.141	3	None	None	None	Nor
D	Low-Copper Pure Iron	A	" " "	0.02	0.026	0.004	0.022	0.002	0.024	7	None	None	None	Nor
O	Low-Copper Open-hearth Steel	A	" " "	0.121	0.536	0.008	0.030	0.249	0.020	12	None	1 (1)	None	Nor
S	Low-Copper Pure Iron, American Rolling Mill Co.	B	" " "	0.02	0.023	0.006	0.022	0.004	0.022	14	None	5 (1)	None	7 (
X	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.055	0.007	0.031	0.004	0.027	14	None	None	None	Nor
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.055	0.139	0.021	0.218	0.020	3	None	None	None	Nor
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.063	0.41	0.102	0.044	0.009	0.013	3	None	None	None	Nor
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.077	0.44	0.095	0.036	0.003	0.140	3	None	None	None	Nor
Z	Open-hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.032	0.32	0.063	0.042	.....	0.019	3	None	None	None	Nor
	Total	.....	.....	.....	.....	.....	.....	.....	.....	79	None	2	None	1

---

[1] In preparing this table, sheets below 0.15 per cent copper have been considered as non-copper-bearing, and those above 0.15 per cent copper as copper-bearing.

[a] No failures were recorded at inspections made prior to March 5, 1923; the detail records are accordingly not given here.

[b] Sheet B-4 shows mechanical damage to upper left-hand corner. Previously recorded as failure through error.

1919, 1920, 1921, 1922, 1923, 1924, 1925, 1926, 1927, 1928, 1929, 1930, 1931, 1932, 1933, AND APRIL, 1934, SHEETS EXPOSED OCTOBER 17, 1916.
COMPARING COPPER-BEARING WITH NON-COPPER-BEARING MATERIALS.[1]

Failures on Dates of Inspections															
Oct. 23, 1924. 96 Months	Mar 27, 1925. 101 Months	Oct. 10, 1925 108 Months	Mar 29, 1926. 113 Months	Nov 17, 1926. 121 Months	Mar 21, 1927. 125 Months	Oct. 5, 1927. 132 Months	May 7, 1928. 139 Months	Apr 25, 1929. 150 Months	Oct. 4, 1929 156 Months	Apr 24, 1930 162 Months	Oct. 31, 1930. 168 Months	Apr. 24, 1931. 174 Months	Oct. 20, 1931. 180 Months	Mar. 2, 1932. 185 Months	Oct. 31, 1 192 Mon
No. 16 GAGE SHEETS															
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
No. 22 GAGE SHEETS															
None	None[b]	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	3 (1)	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	1	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	1 (1)	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	8, 9, 14
None	None	3, 4, 5, 9 (4)	2 (1)	6, 11 (2)	None	7, 10 (2)	None	None	12 (1)	None	None	None	None	None	Non
7 (1)	8 (1)	4 (1)	14 (1)	3 (1)	None	13 (1)	6, 11 (2)	1, 2, 9,10 12 (5)	......	......	......	......	......	......	.....
None	None	None	None	None	4 (1)	None	None	None	1 (1)	5 (1)	None	7, 12 (2)	None	None	6, 8 (
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	1, 2, 3 (3)	....	......	......	......	......	......	......	.....
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	Non
None	None	None	None	None	None	None	None	None	None	417 (1)	None	None	None	None	Non
1	1	5	2	3	1	3	5	5	2	2	None	2	None	1	5

TABLE I.—FAILURES AT ANNAPOLIS TESTS. INSPECTIONS OF 1917, 1918, 1919, 1920, 1921, 1922, 1923, 1924, 1925, 1926, 1927, 1928, 1929,

COMPARING COPPER-BEARING WITH NON-COPPER-BEARING MATER

Series	Description	Average Analysis, per cent						Number of Sheets in Test									
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Mar 5. 1923.[a] 77 Months	Oct. 10, 1923. 84 Months	Apr. 18, 1924. 90 Months	Oct. 23, 1924. 96 Months	Mar 27, 1925. 101 Months	Oct 10 1925 108 Months	Mar 29, 1926. 113 Months	Nov 17, 1926. 121 Months	Mar 21, 1927. 125 Months
														No. 16 GAGE SHEETS			
A	Copper-Bearing	0.035	0 03	0.119	0 018	0 125	0.319	12	None	None	None	None	None	None	None	None	None
A	" "	0 074	0 373	0 011	0 026	0 004	0 237	16	None	None	None	None	None	None	None	None	None
A	" "	0.059	0 371	0 095	0.066	0 006	0.247	16	None	None	None	None	None	None	None	None	None
A	" "	0.108	0 433	0 085	0 043	0 005	0 234	18	None	None	None	None	None	None	None	None	None
A	" "	0.023	0 026	0 005	0 028	0 005	0.236	12	None	None	None	None	None	None	None	None	None
B	" "	0.080	0 313	0 009	0 020	0 006	0 223	14	None	None	None	None	None	None	None	None	None
B	" "	0.018	0 066	0 008	0 028	0 005	0.239	14	None	None	None	None	None	None	None	None	None
B	" "	0 018	0 046	0 007	0 019	0.004	0.299	14	None	None	None	None	None	None	None	None	None
B	" "	0 113	0.413	0 109	0 045	.....	0 167	2	None	None	None	None	None	None	None	None	None
B	" "	0 080	0.34	0 091	0 036	.....	0.293	3	None	None	None	None	None	None	None	None	None
B	" "	0 073	0.305	0 089	0 045	None	0.532	2	None	None	None	None	None	None	None	None	None
B	" "	0 074	0 39	0 069	0 072	....	0 255	3	None	None	None	None	None	None	None	None	None
B	" "	0 077	0 363	0 057	0 080	0 002	0 652	2	None	None	None	None	None	None	None	None	None
B	" "	0.06	0.42	0.050	0.048	Trace	0.363	2	None	None	None	None	None	None	None	None	None
.....	....	.....	.....	.....	.....	.....	.....	130	None	None	None	None	None	None	None	None	None
A	Non-Copper-Bearing	0 043	0 419	0 083	0 042	0 004	0 012	18	None	None	None	None	None	None	None	None	None
A	" " "	0 056	0 349	0 022	0 048	0 037	0 113	17	None	None	None	None	None	None	None	None	None
A	" " "	0 019	0 029	0 004	0 032	0 003	0 067	12	None	None	None	None	None	None	None	None	None
A	" " "	0 019	0 028	0 004	0 027	0 004	0 028	19	None	None	None	None	None	None	None	None	None
A	" " "	0 108	0 371	0 009	0 029	0 007	0 029	12	None	None	None	None	None	None	None	None	None
B	" " "	0 017	0 414	0 010	0 029	0 007	0 057	14	None	None	None	None	None	None	None	None	None
B	" " "	0 017	0 021	0 006	0 021	0 006	0 025	14	None	None	None	None	None	None	None	None	None
B	" " "	0 021	0 062	0 008	0 030	0 005	0 028	14	None	None	None	None	None	None	None	None	None
B	" " "	0 03	0 051	0 123	0 019	0 203	0 023	3	None	None	None	None	None	None	None	None	None
B	" " "	0 08	0 43	0 080	0 031	0 008	0 014	3	None	None	None	None	None	None	None	None	None
B	" " "	0.047	0.389	0.040	0.027	0.007	0.033	3	None	None	None	None	None	None	None	None	None
.....	....	.....	.....	.....	.....	.....	.....	129	None	None	None	None	None	None	None	None	None
														No 22 GAGE SHEETS			
A	Copper-Bearing	0 06	0 27	0 014	0 053	0 006	0 187	9	None	None	None	None	None[b]	None	None	None	None
A	" "	0 015	0 028	0 006	0 036	0 003	0 194	9	None	None	None	None	None	None	None	None	None
A	" "	0 033	0 034	0 114	0 021	0 134	0 283	11	None	None	None	None	None	None	None	None	None
A	" "	0 069	0 387	0 016	0 027	0 004	0 244	16	None	None	None	None	None	None	None	None	None
A	" "	0 041	0 365	0 097	0 068	0 008	0 252	16	None	None	None	None	None	None	None	None	None
A	" "	0 107	0 447	0 091	0 046	0 004	0 237	16	None	None	None	None	None	None	None	None	None
B	" "	0 093	0 419	0 013	0 041	0 011	0 185	14	None	None	None	None	None	None	None	None	None
B	" "	0 083	0 313	0 009	0 020	0 005	0 227	14	None	None	None	None	None	None	None	None	None
B	" "	0 017	0 074	0 008	0 037	0 005	0 260	14	None	None	None	None	None	None	None	None	None
B	" "	0 018	0 051	0 007	0 021	0 005	0 304	14	None	None	None	None	None	None	None	None	None
B	" "	0 058	0 37	0 093	0 043	0 009	0 269	3	None	None	None	None	None	None	None	None	None
B	" "	0 055	0 38	0 110	0 046		0 527	3	None	None	None	None	None	None	None	None	None
B	" "	0 067	0 351	0 045	0 052	0 003	0 187	3	None	None	None	None	None	None	None	None	None
B	" "	0 065	0 35	0 050	0 059	0 003	0 264	3	None	None	None	None	None	None	None	None	None
B	" "	0.073	0.42	0.052	0.054	Trace	0.641	3	None	None	None	None	None	None	None	None	None
.....	....	.....	.....	.....	.....	.....	.....	148	None	None	None	None	None	None	None	None	None
A	Non-Copper-Bearing	0 038	0 386	0 089	0 040	0 007	0 014	14	None	None	None	None	None	None	None	None	None
A	" " "	0 09	0 38	0 017	0 062	0 036	0 084	3	None	None	None	None	None	None	None	None	None
A	" " "	0 01	0 028	0 002	0 027	0 002	0 141	3	None	None	None	None	None	None	None	None	None
A	" " "	0 02	0 026	0 004	0 022	0 002	0 024	7	None	None	None	None	None	None	None	None	None
A	" " "	0 121	0 536	0 008	0 030	0 249	0 020	12	None	1 (1)	None	None	None	3, 4, 5. 9 (4)	2 (1)	6, 11 (2)	None
B	" " "	0 02	0 023	0 006	0 022	0 004	0 022	14	None	5 (1)	None	7 (1)	8 (1)	4 (1)	14 (1)	3 (1)	None
B	" " "	0 021	0 055	0 007	0 031	0 004	0 027	14	None	None	None	None	None	None	None	None	4 (1)
B	" " "	0 03	0 055	0 139	0 021	0 218	0 020	3	None	None	None	None	None	None	None	None	None
B	" " "	0 063	0 41	0 102	0 044	0 009	0 013	3	None	None	None	None	None	None	None	None	None
B	" " "	0 077	0 44	0 095	0 036	0.003	0 140	3	None	None	None	None	None	None	None	None	None
B	" " "	0.032	0.32	0.063	0.042	.....	0.019	3	None	None	None	None	None	None	None	None	None
.....	....	.....	.....	.....	.....	.....	.....	79	None	2	None	1	1	5	2	3	1

n considered as non-copper-bearing, and those above 0.15 per cent copper as copper-bearing.

23. the detail records are accordingly not given here.

viously recorded as failure through error.

PLATE I.
PROCEEDINGS, AM. SOC. TESTING MATS.,
VOL. 34, PART I
REPORT OF COMMITTEE A-5
ATMOSPHERIC CORROSION TESTS

1929, 1930, 1931, 1932, 1933, AND APRIL, 1934, SHEETS EXPOSED OCTOBER 17, 1916.
MATERIALS.[1]

Failures on Dates of Inspections															Number of Sheets Failed in Test
21, 1927. Months	Oct. 5, 1927. 132 Months	May 7, 1928. 139 Months	Apr 25, 1929 150 Months	Oct. 4, 1929 156 Months	Apr 24, 1930 162 Months	Oct. 31, 1930. 168 Months	Apr. 24, 1931. 174 Months	Oct. 20, 1931. 180 Months	Mar. 2, 1932. 185 Months	Oct. 31, 1932. 192 Months	Apr. 3, 1933. 198 Months	Oct. 27, 1933. 204 Months	Apr. 26, 1934. 210 Months		
None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	1, 2 (2)	None	None	2
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	3 (1)	None	1 (1)	None	None	2
one	None	None	None	None	None	None	None	None	None	None	None	2, 3 (2)	1 (1)	3
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	1	None	3	2	1	7
one	None	None	None	None	None	None	None	None	1 (1)	None	2, 3 (2)	4, 7, 10 (3)	None	6
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	None	None	None	None	None	None	None	None	17 (1)	1
one	None	None	None	None	None	None	None	None	None	8, 9, 14 (3)	None	None	None	3
one	7, 10 (2)	None	None	12 (1)	None	None	None	None	None	None	None	8 (1)	None	12
one	13 (1)	6, 11 (2)	1, 2, 9,10 12 (5)	......	......	......	......	......	......	......	......	None	None	14 (all)
(1)	None	None	None	1 (1)	5 (1)	None	7, 12 (2)	None	None	6, 8 (2)	2, 3 (2)	13 (1)	9, 10 (2)	12
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	1, 2, 3 (3)	....	......	......	......	......	......	......	......	......	None	None	3 (all)
one	None	None	None	None	None	None	None	None	None	None	None	None	None	None
one	None	None	None	None	417 (1)	None	None	None	None	None	None	419 (1)	None	2
1	3	5	5	2	2	None	2	None	1	5	4	6	3	53

Table I.—Report on Total Immersion Tests. Sheets Exposed Ma

No. 16 Gage S

Group	Designation	Series	Description	Average Analysis, per cent					
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper
AA	Bessemer Steel	A	Non-Copper-Bearing	0.030	0.420	0.085	0.040	0.003	0.01
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.080	0.440	0.080	0.032		0.01
II	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.060	0.360	0.091	0.066	0.005	0.25
ZZ2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.078	0.340	0.091	0.036		0.28
BB	Open-Hearth Steel	A	Non-Copper-Bearing	0.058	0.359	0.022	0.049	0.005	0.10
FF	Open-Hearth Steel	A	" " "	0.280	0.500	0.027	0.038	0.010	0.03
OO	Low-Copper Open-Hearth Steel	A	" " "	0.110	0.360	0.008	0.029	trace	0.02
MM	Open-Hearth Steel, Alan Wood Steel Co	B	" " "	0.111	0.400	0.010	0.028	0.011	0.05
ZZ4	Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.047	0.389	0.040	0.027	0.007	0.03
GG	Open-Hearth Steel	A	Copper-Bearing	0.290	0.510	0.028	0.039	0.010	0.21
HH	Copper-Bearing Basic Open-Hearth Steel	A	" "	0.069	0.371	0.010	0.026	0.004	0.24
TT	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.087	0.330	0.009	0.019	0.008	0.23
ZZ5	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.075	0.390	0.070	0.073		0.25
CC	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.020	0.027	0.005	0.033	0.003	0.07
DD	Low-Copper Pure Iron	A	" " "	0.019	0.025	0.004	0.027	0.003	0.02
SS	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.015	0.021	0.006	0.020	0.005	0.02
XX	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.028	0.060	0.009	0.028	0.006	0.03
CCC	Copper-Bearing Pure Iron	A	Copper-Bearing	0.018	0.028	0.005	0.032	0.006	0.26
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.014	0.075	0.006	0.028	0.007	0.25
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.009	0.050	0.008	0.018		0.28
KK	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.100	0.460	0.085	0.039		0.23
EE	Puddled Iron	A	Copper-Bearing	0.033	0.026	0.111	0.019	0.109	0.30
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.050	0.124	0.019	0.210	0.02
	Total Failures to Date								

---

[a] All specimens in the inspection on these dates were sand blasted to facilitate inspection.

PLATE II.
PROCEEDINGS, AM. SOC. TESTING MATS.
VOL. 34, PART I.
REPORT OF COMMITTEE A-5:
TOTAL IMMERSION TESTS.

ed March 1, 1927, in Sea Water at U. S. Naval Station, Key West, Fla.

3 Gage Sheets

		Number of Sheets in Test	Failures on Dates of Inspections																									
	Copper		Sept. 6, 1929, 921 Days	Oct. 7, 1929,[a] 952 Days	Nov. 7, 1929, 983 Days	June 6, 1930, 1194 Days	Sept. 6, 1930, 1286 Days	Jan. 8, 1931,[a] 1410 Days	Mar. 10, 1931, 1471 Days	Jan. 13, 1932,[a] 1780 Days	Feb. 12, 1932, 1810 Days	Mar. 14, 1932, 1840 Days	July 13, 1932, 1961 Days	Aug. 12, 1932, 1990 Days	Sept. 14, 1932, 2024 Days	Nov. 14, 1932, 2085 Days	Jan. 11, 1933,[a] 2143 Days	Mar. 14, 1933, 2205 Days	Apr. 15, 1933, 2237 Days	May 15, 1933, 2267 Days	June 15, 1933, 2298 Days	July 15, 1933, 2328 Days	Aug. 14, 1933, 2358 Days	Sept. 19, 1933, 2394 Days	Oct. 17, 1933, 2422 Days	Nov. 16, 1933, 2452 Days	Dec. 15, 1933, 2481 Days	Jan. 22, 1934,[a] 2519 Days
3	0.012	6								1, 13																		28
	0.014	6		1													2	1			2					5		4
5	0.254	6										1							10									18
	0.287	6								201				205		204	201			202		206						
5	0.109	6														9												
0	0.034	6								11	10											10						
e	0.026	6			3			13									6											
1	0.053	6							2																	11		
7	0.033	6	418				417			417, 419				419	418													
0	0.217	6																										
4	0.248	6																	11		4							22
8	0.239	6																										13, 15
	0.257	6								501														501		503		505
3	0.078	6										12																
3	0.028	6				24					32																	
5	0.023	6		6				21																				
6	0.030	6		13	11																						2	
6	0.262	6														18					8							13
7	0.250	6																										
	0.288	6																							1, 34			
	0.230	6								3			6										16	23		20		
9	0.307	6																				1						2, 13
0	0.021	6						1									6										2	2
		138	1	3	2	1	1	3	1	8	2	2	1	2	1	3	4	1	2	1	3	3	1	2	2	4	2	11
..	....	...	1	4	6	7	8	11	12	20	22	24	25	27	28	31	35	36	38	39	42	45	46	48	50	54	56	67

TABLE II.—REPORT ON TOTAL IMMERSION TESTS. SHEETS EXPOSED MARC

No. 16 Gage

Group	Designation	Series	Description	Average Analysis, per cent					
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper
AA	Bessemer Steel	A	Non-Copper-Bearing	0.053	0.420	0.087	0.041		0.0
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.078	0.412	0.100	0.038		0.0
II	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.057	0.390	0.098	0.066		0.2
ZZ2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.088	0.317	0.092	0.045	0.000	0.2
BB	Open-Hearth Steel	A	Non-Copper-Bearing	0.063	0.338	0.030	0.057	0.078	0.1
FF	Open-Hearth Steel	A	" " "	0.277	0.500	0.027	0.038	0.010	0.0
OO	Low-Copper Open-Hearth Steel	A	" " "	0.117	0.377	0.010	0.027	0.005	0.0
MM	Open-Hearth Steel, Alan Wood Steel Co	B	" " "	0.105	0.420	0.011	0.032	0.005	0.0
ZZ4	Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.028	0.392	0.042	0.029		0.0
GG	Open-Hearth Steel	A	Copper-Bearing	0.293	0.506	0.028	0.039	0.010	0.2
HH	Copper-Bearing Basic Open-Hearth Steel	A	" "	0.073	0.372	0.015	0.027		0.2
TT	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.076	0.305	0.010	0.020		0.2
ZZ5	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.066	0.373	0.056	0.066		0.2
CC	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.020	0.031	0.004	0.033		0.0
DD	Low-Copper Pure Iron	A	" " "	0.020	0.034	0.004	0.026		0.0
SS	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.014	0.017	0.006	0.023		0.0
XX	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.019	0.053	0.008	0.031		0.0
CCC	Copper-Bearing Pure Iron	A	Copper-Bearing	0.018	0.027	0.005	0.027	0.005	0.2
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.013	0.066	0.010	0.033		0.2
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.016	0.033	0.007	0.022		0.2
KK	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.120	0.418	0.085	0.042		0.2
EE	Puddled Iron	A	Copper-Bearing	0.030	0.040	0.124	0.018	0.130	0.3
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.052	0.123	0.018	0.193	0.0
	Total Failures to Date	....	....	.....	.....	.....	.....	.....	.....

[a] All specimens in the inspection on these dates were sand blasted to facilitate inspection.

[b] All specimens in the inspection on this date had been sand blasted on May 27, 1930, and October 15, 1930.

[c] All specimens in the inspection on this date had been sand blasted on April 6. 1931

[d] All specimens in the inspection on this date had been sand blasted on April 5, 1932.

PLATE III.
PROCEEDINGS. AM. SOC. TESTING MATS.
VOL. 34. PART I
REPORT OF COMMITTEE A-5:
TOTAL IMMERSION TESTS.

MARCH 7, 1927, IN SEA WATER AT U. S. NAVY YARD, PORTSMOUTH, N. H.

16 GAGE SHEETS

nt		Number of Sheets in Test	Failures on Dates of Inspections																								
ilicon	Copper		Dec. 4, 1929,[a] 1003 Days	Feb. 5, 1930, 1066 Days	Mar. 1, 1930, 1090 Days	May 1, 1930, 1151 Days	Jan. 5, 1931,[b] 1400 Days	Feb. 5, 1931 1431 Days	Aug. 6, 1931,[c] 1615 Days	Sept. 5, 1931, 1646 Days	Oct. 5, 1931, 1676 Days	Dec. 5, 1931, 1737 Days	Jan. 5, 1932, 1768 Days	Feb. 5, 1932, 1799 Days	July 5, 1932,[d] 1497 Days	Aug. 5, 1932, 1978 Days	Sept. 5, 1932,[a] 2009 Days	Dec. 6, 1932, 2101 Days	Jan. 5, 1933, 2131 Days	Mar. 6, 1933, 2191 Days	Apr. 5, 1933,[a] 2221 Days	June 5, 1933, 2282 Days	Aug. 7, 1933, 2345 Days	Sept. 5, 1933,[a] 2374 Days	Oct. 5, 1933, 2404 Days	Dec. 5, 1933, 2465 Days	Feb. 6, 1934, 2528 Days
	0.013	6															31							34			
	0.013	6											422							5							
	0.247	6																									
.000	0.276	6																									213
078	0.122	6										39															
010	0.034	6									10							11						11			
005	0.030	6			15					33			32	35		34					28						
.005	0.052	6															27							40	31		
	0.028	6						420							422									420			
.010	0.217	6																									
	0.228	6		32														37, 44									
	0.226	6							21															27			
	0.227	6																									510
	0.065	6				18															25						
	0.028	6	50			35						52			42												
	0.028	6																	27								42
	0.027	6											15			16											
.005	0.221	6															21										
	0.243	6																									
	0.289	6																						37			
	0.240	6															26					47					
130	0.334	6										15											17				
193	0.024	6					7				8													9		9, 8	
		138	1	1	1	2	1	1	1	1	2	3	3	1	2	2	4	3	1	1	2	1	1	7	1	2	3
......	......	...	1	2	3	5	6	7	8	9	11	14	17	18	20	22	26	29	30	31	33	34	35	42	43	45	48

REPORT OF SUBCOMMITTEE V ON TOTAL IMMERSION TESTS

Sea Water Immersion Tests:

Steel Sheets.—During the past year the regular monthly inspections of the No. 16 gage steel sheets immersed in sea water since March, 1927, at the U. S. Naval Station, Key West, Fla., and the U. S. Navy Yard, Portsmouth, N. H., have been made and the number of failures that have been observed are recorded in Tables I and II (Plates II and III). The tests of the No. 22 gage steel sheets also exposed at these locations since 1927 have been completed. The detailed record of failures of the No. 22 sheets exposed at Key West appeared in the 1933 report[1] and of those at Portsmouth, N. H., in the 1932 report.[2] It is considered desirable to defer general conclusions until all the specimens have failed.

Riveted Test Plates.—The riveted test plates have now been exposed in sea water for more than seven years. Inspections were made at Portsmouth, N. H., on September 8 to 18, 1933, and at Key West on February 6 to 9, 1934. The plates were photographed as removed from the water, also after cleaning by scraping and light sand blasting. Wax impressions of the corroded plates and rivets were taken and copper replicas will be made. This test will apparently continue for some further time before conclusions can be drawn.

Steel Tubes.—The tubes with and without copper have also been exposed for seven years. They are being regularly inspected at the same time as the riveted plates. Corrosion is proceeding but slowly and no definite result can yet be reported.

The question of the new tests on No. 22 gage sheets that had been proposed a year a year ago was discussed in detail by the subcommittee at a meeting held during the 1934 annual meeting. The subcommittee felt that the proposed tests were of a nature that would not warrant the expense and time required and voted unanimously at the meeting to eliminate them from the current program.

Respectfully submitted on behalf of the subcommittee,

F. B. Olcott,
Chairman.

---

[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 33, Part I, p. 144 (1933).

[2] *Proceedings,* Am. Soc. Testing Mats., Vol. 32, Part I, p. 105 (1932).

REPORT OF SUBCOMMITTEE VI ON SPECIFICATIONS FOR METALLIC-COATED PRODUCTS

Subcommittee VI is responsible for the following two tentative specifications proposed in 1932 as tentative revisions of existing standards, which it recommends be continued as tentative for another year:

Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A 116 – 32 T)

Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Barbed Wire (A 121 – 32 T)

The subcommittee felt that it was not in position to revise these tentative specifications further during the past year or to recommend their adoption as standard at this time. During the past year, however, a representative group of the personnel of Subcommittee VI directly interested in these products has served on a special committee of Subcommittee VIII on Field Tests of Metallic Coatings charged to inaugurate outdoor exposure tests of galvanized wire and wire products. Considerable work has been done by the special committee in an effort to determine the controlling factors affecting the serviceability of fencing and barbed wire, and to plan tests which will furnish the engineering information necessary to evaluate specification requirements in terms of service life.

Subcommittee VI felt that further consideration of these two tentative specifications could most profitably be taken up after this wire test committee of Subcommittee VIII had completed its survey of the service requirements of fencing and barbed wire and its plan of testing them. It is anticipated that definite action on these specifications will be taken during the ensuing year.

A special group was appointed in 1931 by this subcommittee to cooperate with the American Electro-Platers Society in determining the need for specifications for certain electroplated coatings, such as zinc and cadmium, and if desirable to prepare draft specifications for submission to Subcommittee VI for consideration. This joint committee has done considerable work during the past year and plans to have one or more specifications ready for study in the near future.

Respectfully submitted on behalf of the subcommittee,

F. F. Farnsworth,
Chairman.

REPORT OF SUBCOMMITTEE VIII ON FIELD TESTS OF METALLIC COATINGS

Subcommittee VIII has held one general meeting since the 1933 annual meeting of the Society. Progress has been made in its atmospheric test program, and it is the intention of the present report to record this progress.

GALVANIZED SHEETS

A Special Committee on Inspection of Galvanized Sheets, under the chairmanship of Mr. M. E. McDonnell, has made several inspections during the year at the locations where galvanized sheets are exposed.

The specimens at Altoona, Pa., were inspected on April 25, 1933; July 25, 1933; October 24, 1933; and January 23, 1934.

The dates on which the specimens at Pittsburgh (Brunot Island), Pa., and Sandy Hook, N. J., were inspected are shown in Tables II and III.

The specimens at State College, Pa., were inspected April 25, 1933, and October 24, 1933.

The specimens at Key West, Fla., were inspected on February 6, 1934, by Messrs. M. E. McDonnell and G. N. Schramm (representing Mr. E. S. Taylerson).

At Altoona all of the coatings had failed locally at the time the 1933 report[1] was prepared. Table I, covering these same data, shows the time at which the first local failure was observed on each individual specimen. The weight of coating on these sheets as indicated by weight tests and triple spot tests was published in the 1927 report.[2] Some of the variation in the time at which rust was first observed is unquestionably due to lack of uniformity and deviation from the nominal weight of coating. For example, the 2.5-oz., No. 22-gage sheets are generally close to the nominal coating weight with the exception of sheet "T" (on which the coating is heavy) and sheet "V" (on which the coating is light). The weight of coating in the 0.75-oz. class varied due to the difference in practice of the various manufacturers.

From an examination of these data, it would appear that the time for the first local failure is dependent on the weight and uni-

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 149 (1933).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 204 (1927).

TABLE I.—RECORD OF FIRST COATING FAILURES ON CORRUGATED ZINC-COATED SHEETS OF VARIOUS BASE MATERIALS AND VARIOUS WEIGHTS OF COATING. AT ALTOONA, PA.; SHEETS EXPOSED APRIL 22, 1926.

Description[a]	Specimen	First Coating Failures, Time in Years											
		Identification of Base Material[b]									All Base Materials		
		R	V	N	T	Y	S	C	K	W	Avg.	Min.	Max.
No. 16 Gage, 2.50 oz. per sq. ft.	T....	....	4.27	....	4.52	4.27	4.27	....	4.27	....	4.32	4.27	4.52
	B....	....	4.27	....	4.79	4.52	4.27	....	4.27	....	4.42	4.27	4.79
	Avg..	....	4.27	....	4.66	4.40	4.27	....	4.27	....	4.37	....	....
No. 22 Gage, 2.50 oz. per sq. ft.	T....	4.27	4.27	4.27	5.50	3.52	4.27	4.00	4.27	5.25	4.40	3.52	5.50
	B....	4.52	4.79	3.52	6.26	3.25	4.79	5.78	4.52	5.25	4.74	3.25	6.26
	Avg..	4.40	4.53	3.90	5.88	3.38	4.53	4.89	4.40	5.25	4.57	....	....
No. 22 Gage, 2.00 oz. per sq. ft.	T....	3.25	3.25	3.25	3.52	3.25	4.27	3.25	4.27	3.52	3.54	3.25	4.27
	B....	3.25	4.27	3.52	3.52	4.27	4.27	4.27	4.27	4.27	3.99	3.25	4.27
	Avg..	3.25	3.76	3.38	3.52	3.76	4.27	3.76	4.27	3.90	3.77	....	....
No. 22 Gage, 1.50 oz. per sq. ft.	T....	3.25	2.27	3.25	2.27	2.53	3.00	2.53	3.25	3.25	2.84	2.27	3.25
	B....	3.25	2.53	3.25	2.53	3.25	3.25	3.25	3.25	3.25	3.09	2.53	3.25
	Avg..	3.25	2.40	3.25	2.40	2.88	3.13	2.88	3.25	3.25	2.97	....	....
No. 22 Gage, 1.25 oz. per sq. ft.	T....	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.53	2.27	2.30	2.27	2.53
	B....	2.27	2.27	2.27	2.27	2.53	3.00	2.53	3.25	2.27	2.52	2.27	3.25
	Avg..	2.27	2.27	2.27	2.27	2.40	2.64	2.40	2.88	2.27	2.41	....	....
No. 22 Gage, 0.75 oz. per sq. ft.	T....	....	1.43	1.43	1.43	2.27	2.03	1.43	2.27	....	1.76	1.43	2.27
	B....	....	2.27	1.43	2.27	2.27	2.27	1.43	2.27	....	2.03	1.43	2.27
	Avg..	....	1.85	1.43	1.85	2.27	2.15	1.43	2.27	....	1.89	....	....
No. 28 Gage, 0.75 oz. per sq. ft.	T....	....	....	2.03	2.03	1.43	2.03	....	2.27	....	1.96	1.43	2.27
	B....	....	....	2.27	2.27	2.27	2.27	....	2.27	....	2.27	2.27	2.27
	Avg..	....	....	2.15	2.15	1.85	2.15	....	2.27	....	2.11	....	....

[a] For deviation in coating weights on individual sheets, see *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 204 (1927).

[b] For approximate composition of base material, see Table VII, p. 165.

TABLE II.—RECORD OF COATING FAILURES ON SANDY HOOK, N. J., TEST RACK. SHEETS EXPOSED MAY 20, 1926.

Description[a]	Number of Specimens in Test	Apr. 24, 1930, 3.93 years	Oct. 30, 1930, 4.45 years	Apr. 22, 1931, 4.93 years	Oct. 21, 1931, 5.42 years	Apr. 27, 1932, 5.94 years	Oct. 26, 1932, 6.45 years	Apr. 26, 1933, 6.93 years	Oct. 25, 1933, 7.43 years	Total Number of Failures	Average Life in Years
No. 16 Gage, 2.50 oz. per sq. ft.	10	none	none	none	none	none	none	none	none	none	....
No. 22 Gage, 2.50 oz. per sq. ft.	18	none	none	none	none	none	none	none	none	none	....
No. 22 Gage, 2.00 oz. per sq. ft.	18	none	none	none	none	none	none	none	none	none	....
No. 22 Gage, 1.50 oz. per sq. ft.	18	none	none	none	none	none	1	3	9	13	(7.43)[a]
No. 22 Gage, 1.25 oz. per sq. ft.	18	none	none	none	1	3	3	4	7	18	6.80
No. 22 Gage, 0.75 oz. per sq. ft.	14	none	10	1	2	none	1	..	..	14	4.77
No. 28 Gage, 0.75 oz. per sq. ft.	10	none	6	1	2	none	1	..	..	10	4.89
	106	none	16	2	5	3	6	7	16	..	
Total Failures to Date.....	..	none	16	18	23	26	32	39	55	55	

[a] Figures shown in parentheses are not to be considered as final.

TABLE III.—RECORD OF COATING FAILURES ON BRUNOT ISLAND, PITTSBURGH, PA., TEST RACK. SHEETS EXPOSED APRIL 21, 1926.

Description	Number of Specimens in Test	Sept. 27, 1927, 1.43 years	Apr. 30, 1928, 2.03 years	July 26, 1928, 2.27 years	Oct. 29, 1928, 2.53 years	July 22, 1929, 3.25 years	Oct. 28, 1929, 3.52 years	Feb. 11, 1930, 3.81 years	Apr. 21, 1930, 4.00 years	July 27, 1930, 4.27 years	Oct. 30, 1930, 4.52 years	Feb. 4, 1931, 4.79 years	Apr. 20, 1931, 5.00 years	July 20, 1931, 5.25 years	Oct. 19, 1931, 5.50 years	Jan. 29, 1932, 5.78 years	Apr. 25, 1932, 6.02 years	July 25, 1932, 6.26 years	Apr. 24, 1933, 7.01 years	July 24, 1933, 7.26 years[a]	Total Number of Failures	Average Life in Years
No. 16 Gage, 2.50 oz. per sq. ft......	12	none	none	none	none	none	none	none	none	1	none	2	1	4	3	1	..	..	..	..	12	5.18
No. 22 Gage, 2.50 oz. per sq. ft......	18	none	none	none	none	none	none	none	1	1	1	none	none	4	4	1	none	2	1	1	16	(5.80)[b]
No. 22 Gage, 2.00 oz. per sq. ft......	18	none	none	none	none	none	1	none	2	3	6	3	none	1	none	2	..	..	..	..	18	4.59
No. 22 Gage, 1.50 oz. per sq. ft......	18	none	none	none	none	10	3	3	1	1	..	..	..	..	..	..	..	..	..	..	18	3.49
No. 22 Gage, 1.25 oz. per sq. ft......	18	none	none	none	2	16	..	..	..	..	..	..	..	..	..	..	..	..	..	..	18	3.17
No. 22 Gage, 0.75 oz. per sq. ft......	14	none	5	9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	14	2.18
No. 28 Gage, 0.75 oz. per sq. ft......	10	none	2	8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	2.22
	108	none	7	17	2	26	4	3	4	6	7	5	1	9	7	4	none	2	1	1		
Total Failures to Date..........	......	none	7	24	26	52	56	59	63	69	76	81	82	91	98	102	102	104	105	106	106	

---

[a] No additional failures were found at inspections made October 23, 1933 (7.51 years) and January 22, 1934 (7.76 years).

[b] Figures shown in parentheses are not to be considered as final.

formity of distribution of the coating and not on the composition of the base metal. This statement is based on the data now available from the Altoona test location. Data similar to these will ultimately be available from four other test locations and may or may not bear out the present indications at Altoona.

Considerable interest has been shown from time to time in the relationship between weight and life of coating. Figure 1 has been prepared from the Altoona data. The average time required for the first local failure on the specimens in a given class has been plotted against the average triple spot test for that class. It will be noticed that the data can be represented satisfactorily by a straight line, but it should also be noticed that the line does not pass through the origin.

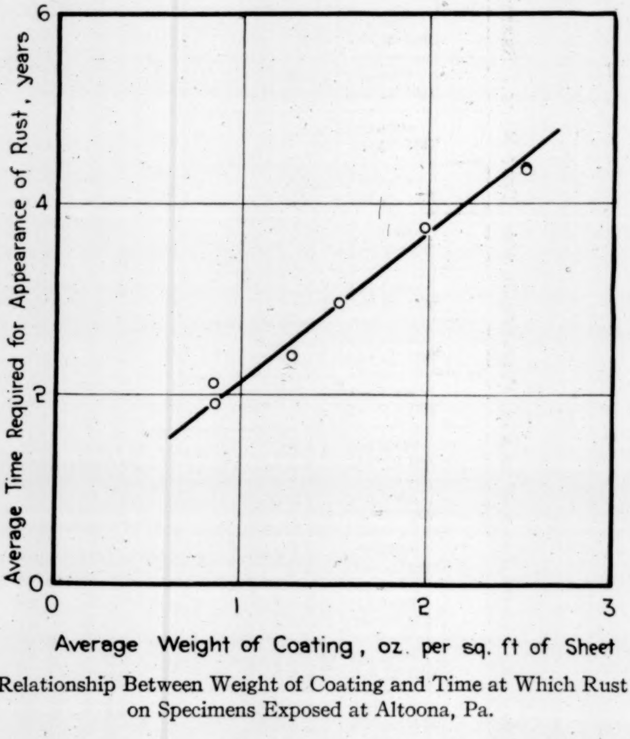


FIG. 1.—Relationship Between Weight of Coating and Time at Which Rust Appears on Specimens Exposed at Altoona, Pa.

It is planned that the inspections at Altoona will be continued until the coatings have completely failed and the base metal sheets are perforated.

At Sandy Hook there have been eleven new failures in the 1.25-oz. coating class and twelve in the 1.50-oz. coating class during the year.

Table II shows the total number of specimens on which rust has been observed at this location. It will be observed that no rusting has been found yet in the heavier coating classes.

TABLE IV.—PROGRESSIVE DEVELOPMENT OF RUST ON ZINC-COATED SHEETS AT ALTOONA, PA. SHEETS EXPOSED APRIL 22, 1926.

Average Percentage of Exposed Areas Rusted at Various Inspections.

Description	Number of Specimens in Test	May 1, 1928, 2.03 years	Oct. 30, 1928, 2.53 years	Apr. 23, 1929, 3.00 years	Oct. 29, 1929, 3.52 years	Apr. 22, 1930, 4.00 years	Oct. 29, 1930, 4.52 years	Apr. 21, 1931, 5.00 years	Oct. 20, 1931, 5.50 years	Apr. 26, 1932, 6.01 years	Oct. 25, 1932 6.51 years	Apr. 25, 1933, 7.01 years	Oct. 24, 1933, 7.51 years
No. 16 Gage, 2.50 oz. per sq. ft.	10	none	none	none	none	none	2.7	4.1	14.0	18.4	23.9	34.7	56.8
No. 22 Gage, 2.50 oz. per sq. ft.	18	none	none	none	0.3	0.5	4.6	5.6	15.7	21.1	24.6	38.8	59.4
No. 22 Gage, 2.00 oz. per sq. ft.	18	none	none	none	1.9	2.2	21.9	23.8	60.7	74.5	82.8	89.9	97.1
No. 22 Gage, 1.50 oz. per sq. ft.	18	none	0.8	1.9	42.8	57.5	94.5	97.1	99.4	99.7	..	..	..
No. 22 Gage, 1.25 oz. per sq. ft.	18	none	3.5	11.2	85.0	93.5	99.6	..	..	..	..	..	..
No. 22 Gage, 0.75 oz. per sq. ft.	14	3.4	83.2	94.1	100	..	..	..	..	..	..	..	..
No. 28 Gage, 0.75 oz. per sq. ft.	10	1.7	85.1	98.4	..	..	..	..	..	..	..	..	..

TABLE V.—PROGRESSIVE DEVELOPMENT OF RUST ON ZINC-COATED SHEETS AT BRUNOT ISLAND, PITTSBURGH, PA. SHEETS EXPOSED APRIL 21, 1926.

Average Percentage of Exposed Areas Rusted at Various Inspections.

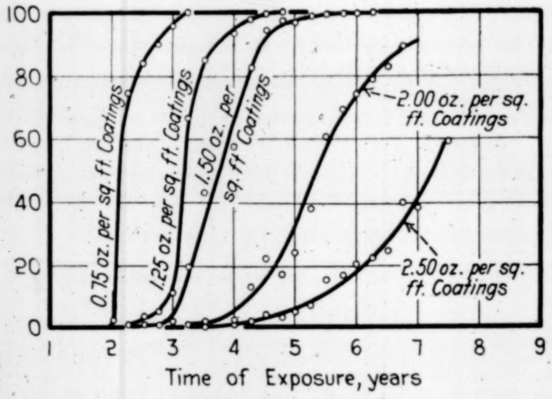
Description	Number of Specimens in Test	Apr. 30, 1928, 2.03 years	Oct. 29, 1928, 2.53 years	Apr. 22, 1929, 3.00 years	Oct. 28, 1929, 3.52 years	Apr. 21, 1930, 4.00 years	Oct. 30, 1930, 4.52 years	Apr. 20, 1931, 5.00 years	Oct. 19, 1931, 5.50 years	Apr. 25, 1932, 6.01 years	Oct. 24, 1932, 6.51 years	Apr. 24, 1933, 7.01 years	Oct. 23, 1933, 7.51 years
No. 16 Gage, 2.50 oz. per sq. ft.	12	none	none	none	none	none	0.1	0.3	1.6	3.8	5.5	8.5	18.7
No. 22 Gage, 2.50 oz. per sq. ft.	18	none	none	none	none	0.1	0.2	0.2	1.2	3.1	4.6	6.6	16.2
No. 22 Gage, 2.00 oz. per sq. ft.	18	none	none	none	0.1	0.4	1.2	3.1	10.2	23.2	28.9	38.5	59.8
No. 22 Gage, 1.50 oz. per sq. ft.	18	none	none	0.1	1.6	8.8	26.0	44.1	70.7	90.3	93.4	96.6	97.9
No. 22 Gage, 1.25 oz. per sq. ft.	18	none	0.1	0.5	11.4	42.9	73.8	81.6	97.0	99.4	99.7	..	..
No. 22 Gage, 0.75 oz. per sq. ft.	14	0.9	27.8	53.0	91.6	99.2	100	..	..	..	..	..	..
No. 28 Gage, 0.75 oz. per sq. ft.	10	1.3	31.8	69.1	95.9	99.6	100	..	..	..	..	..	..

TABLE VI.—PROGRESSIVE DEVELOPMENT OF RUST ON ZINC-COATED SHEETS AT SANDY HOOK, N. J. SHEETS EXPOSED MAY 20, 1926.

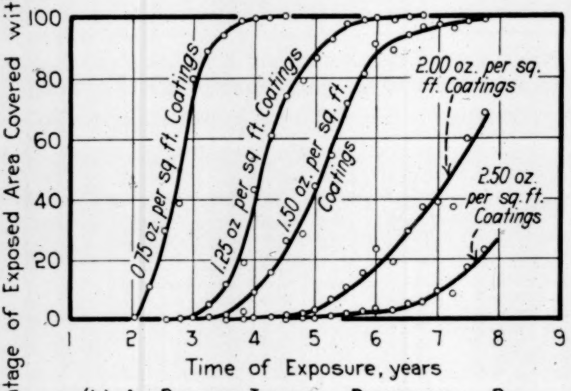
Average Percentage of Exposed Areas Rusted at Various Inspections.

Description	Number of Specimens in Test	Apr. 23, 1930, 3.92 years	Oct. 30, 1930, 4.45 years	Apr. 22, 1931, 4.92 years	Oct. 21, 1931, 5.42 years	Apr. 27, 1932, 5.94 years	Oct. 26, 1932, 6.43 years	Apr. 26, 1933, 6.93 years	Oct. 25, 1933, 7.43 years
No. 16 Gage, 2.50 oz. per sq. ft.	12	none	none	none	none	none	none	none	none
No. 22 Gage, 2.50 oz. per sq. ft.	18	none	none	none	none	none	none	none	none
No. 22 Gage, 2.00 oz. per sq. ft.	18	none	none	none	none	none	none	none	none
No. 22 Gage, 1.50 oz. per sq. ft.	18	none	none	none	none	none	trace	0.2	1.0
No. 22 Gage, 1.25 oz. per sq. ft.	18	none	trace	trace	trace	trace	trace	0.6	4.9
No. 22 Gage, 0.75 oz. per sq. ft.	14	none	0.9	1.8	15.6	24.4	40.2	43.8	68.7
No. 28 Gage, 0.75 oz. per sq. ft.	10	none	0.5	1.3	14.4	32.7	53.3	55.7	82.3

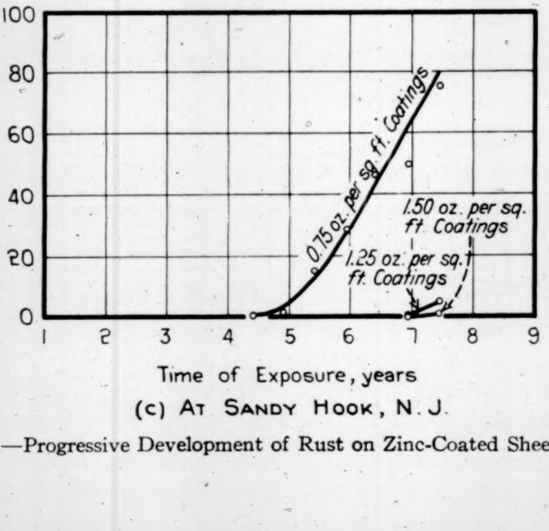
At Brunot Island there have been two new initial coating failures during the year. Table III shows the total number of specimens on which rust has been observed at this location.



(a) AT ALTOONA, PA.



(b) AT BRUNOT ISLAND, PITTSBURGH, PA.



(c) AT SANDY HOOK, N. J.

FIG. 2.—Progressive Development of Rust on Zinc-Coated Sheets.

At State College only one specimen in the 0.75-oz. coating class has shown rust and this was recorded in last year's report. The majority of the sheets with coatings less than 2 oz. now show "yellowed" areas.

At Key West the durability of the zinc-coated sheets seems especially remarkable. No sheet yet shows "yellowed" areas and it is estimated that the amount of white incrustation previously observed is increasing. It will be recalled that all of the uncoated sheets at this location have failed.

Although the Special Committee originally laid its plans to consider the time at which rust first appeared on each specimen as the criterion of coating service, it is now thought that users of galvanized sheets may be as much or more interested in the percentage of exposed area covered with rust at successive inspection periods. To this end Tables IV, V and VI have been included showing progressive development of rust on the exposed surface of the galvanized sheets by coating classes at Altoona, Brunot Island and Sandy Hook. At Altoona and Brunot Island inspections have been made quarterly but the tables have been condensed to show the progressive development of rust at half-year intervals. Each individual figure is an average for all the sheets in the particular weight of coating class and of the estimates made by all of the inspectors present on the date of inspection.

These data are shown graphically in Fig. 2 as smooth curves for each weight of coating class. It is interesting to observe the relative performance of the same coating classes at the three locations where

TABLE VII.—TIME IN YEARS FOR PERFORATIONS OF NO. 22 GAGE, BLACK SHEETS.[a]

Identification	Class of Material	Average Chemical Composition									Brunot Island, Pittsburgh, Pa.	Altoona, Pa.	Key West, Fla.	Sandy Hook, N. J.	State College, Pa.
		Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Silicon, per cent	Copper, per cent	Nickel, per cent	Chromium, per cent	Molybdenum, per cent					
R	Open-Hearth Iron.......	0.011	0.021	0.004	0.018	0.004	0.032	0.023	[d]	0.004[b]	2.03	4.27	3.62	5.94	—
V	Open-Hearth Iron.......	0.018	0.053	0.005	0.032	0.004	0.051	0.045	[d]	0.007[b]	2.27	4.27	3.62	4.93	—
U	Open-Hearth Iron.......	0.015	0.020	0.004	0.024	0.005	0.087	0 106	[d]	0.009[b]	2.53	4.27	3.62	5.42	—
N	Open-Hearth Iron.......	0.013	0.057	0.007	0.029	0.003	0.167	0.057	[d]	0.004[b]	3.00	7.51	3.62	5.94	—
T	Open-Hearth Iron.......	0.016	0.157	0.007	0.028	0.004	0.228	0.073	[d]	0.004[b]	—	—	3.62	6.45	—
Y	Open-Hearth Steel......	0.028	0.346	0.067	0.050	0.005	0.029	0.003[b]	0.013	[c]	2.03	2.03	2.62	3.45	—
S	Open-Hearth Steel......	0.040	0.488	0.072	0.041	0.003	0.051	0.006[b]	0.094	[c]	3.25	—	3.62	—	—
C	Open-Hearth Steel......	0.066	0.458	0.053	0.045	0.003	0.222	0.003[b]	0.000[b]	[c]	—	—	5.73	—	—
K	Open-Hearth Steel......	0.023	0.460	0.066	0.045	0.003	0.268	0.023[b]	0.031	[c]	—	—	4.58	—	—
W	Wrought Iron...........	0.021	0.048	0.143	0.019	0.210	0.025	0.020[b]	[d]	0.003[b]	3.00	5.00	3.62	4.93	—

[a] Blanks in table represent sheets that have not failed as yet. The material has been under observation for 7.75 years.

[b] Average of determinations in one laboratory.

[c] Less than 0.003 per cent; results of one laboratory.

[d] Less than 0.006 per cent; results of one laboratory.

data are available, and also to observe that the weight of coating required for a given amount of protection changes with locality. For example, the 0.75 oz. per sq. ft. coatings at Sandy Hook have given so far about the same service as the 2.00 oz. per sq. ft. coatings at Brunot Island and as the 2.50 oz. per sq. ft. coatings at Altoona.

Uncoated Sheets:

The uncoated sheets have been inspected regularly along with the galvanized sheets. The results of these examinations are shown in Table VII.

COATED HARDWARE, STRUCTURAL SHAPES, TUBULAR GOODS, ETC.

A Special Committee on Inspection of Coated Hardware, Structural Shapes, Tubular Goods, Etc., under the chairmanship of Mr. W. L. Maucher, has made two inspections during the past year. Last year's report gave an extensive tabulation of the inspection data with a summarizing discussion. Since that time additional rusting has occurred but not to an extent that justifies another extensive publication.

ELECTRODEPOSITED COATINGS

Subcommittee VIII has cooperated to a limited extent in an investigation on the protection afforded by electrodeposited coatings on steel. The inspection data are obtained by representatives of a Joint Inspection Committee consisting of: Wm. Blum (chairman), W. Fraine, J. Hay, R. F. Passano, W. M. Phillips, L. H. Rovere, and O. J. Sizelove. Inasmuch as certain portions of this investigation on electrodeposited coatings are closely related to the work of Subcommittee VIII, it has seemed advisable to include in this report a brief summary which will indicate the progress of these investigations.

Nickel and Chromium Finishes.—Most of the specimens plated with coatings consisting of combinations of copper, nickel, and chromium that were exposed in the spring of 1932 have failed badly after two years' exposure at the industrial locations, New York City and Pittsburgh, Pa. At Sandy Hook, N. J., the attack has been more severe than at Key West, Fla. None except very thin coatings have shown marked failure at State College, Pa., or Washington, D. C.

Supplemental specimens exposed for one year in the four severest locations have reproduced closely the results of the first series, a summary of which was given in last year's report.[1]

Zinc and Cadmium Coatings.—In all locations thin coatings (0.0002 in. for example) of zinc or cadmium furnished more protection than did equally thin coatings consisting of copper, nickel, or chromium, although there was marked discoloration of the zinc and cadmium deposits. At New York and Pittsburgh the specimens with thin coatings of either zinc or cadmium showed decided rust within a year. In both locations the specimens plated with cadmium developed rust sooner than those plated with zinc, as shown in Fig. 1 of the paper entitled, "The Harmony of Outdoor Weathering Tests" by R. F. Passano.[1] There have not been sufficient failures of either zinc or cadmium coatings in marine or rural atmospheres to warrant discussion at this time.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 165 (1933).

The program on electrodeposited coatings has included an investigation of several so-called accelerated methods with the idea of determining whether they are suitable for the determination of quality of coating. Stripping methods have also been studied. These phases of the work on electrodeposited specimens are, however, beyond the scope of this subcommittee and detailed consideration will no doubt be given to these points in subsequent reports of Subcommittees VI and VII.

PROPOSED FIELD TEST ON WIRE AND WIRE PRODUCTS

At the June, 1933, meeting, Subcommittee VIII appointed a committee comprising the following to work out details, and begin the wire tests recommended by Mr. W. H. Finkeldey's special committee (now discharged, following acceptance by Subcommittee VIII of its report):

F. F. Farnsworth, *chairman*, Bell Telephone Laboratories, Inc.
A. P. S. Bellis, J. A. Roebling's Sons Co.
J. D. Conover, American Zinc Inst., Inc.
F. M. Crapo, Indiana Steel and Wire Co.
F. C. Elder, American Steel and Wire Co.
W. H. Finkeldey, Singmaster & Breyer
H. E. Smith, Consulting Engineer

An advisory group, to assist the committee in working out a rational test program for farm fencing and barbed wire, was appointed by the chairman, as follows:

R. U. Blasingame, Dept. of Agricultural Engineering, Pennsylvania State College
W. M. Floto, American Steel and Wire Co.
H. F. Hanks, Pittsburgh Steel Co.
H. W. Riley, Dept. of Agricultural Engineering, Cornell University

---

[1] R. F. Passano, "The Harmony of Outdoor Weathering Tests," Symposium on the Outdoor Weathering of Metals and Metallic Coatings, Washington Regional Meeting, Am. Soc. Testing Mats., p. 28 (1934).

Messrs. C. A. Kellogg (Continental Steel Corp.), L. H. Winkler (Bethlehem Steel Co.), and L. W. Hopkins (American Chain Co.) have also given every assistance possible in the planning of these tests.

The committee and those acting with it in an advisory capacity, hereinafter referred to as the "Wire Test Committee," have held several meetings since last June and have drawn up the testing program appended to this report. This program embraces the general plan as outlined by the Finkeldey committee, modified to embrace such comments as were felt would insure that the tests yielded data of maximum value to both producer and consumer.

As now formulated, the plan has received the unanimous approval of the full Wire Test Committee.

The program has since been approved by the entire Subcommittee VIII. Constructive comments will be welcomed by the Wire Test Committee, and should be sent to the chairman promptly.

While all details of the tests are not complete, the Wire Test Committee feels that all major phases of the program are presented in sufficient detail to permit the aims and scope of the tests to be readily understood.

The programs for testing wire strand and chain-link fencing differ little from the Finkeldey committee program.

The following comments relate primarily to farm-field fencing, barbed wire, and unfabricated (plain) wire. They are intended to supplement the earlier report of the Finkeldey committee and to explain the major changes in the testing program which the present Wire Test Committee has seen fit to make. Certain portions of the Finkeldey report have been repeated herein for the sake of continuity of thought, or for emphasis. Generally, no distinction has been made between comments originally appearing in the Finkeldey committee report and those added by the present Wire Test Committee.

The Wire Test Committee agreed that it was primarily interested in characterizing fencing and fence wire from the standpoints of composition of base metal, gage, type of coating, weight of coating, etc. For this reason, the Wire Test Committee believes all samples should be very carefully prepared and should be selected to represent hand-picked samples, rather than as necessarily representing the commercial run of the product. Consequently, limits on the composition of base metal and weight of coating, and the classes of weights of coating have been very carefully chosen. This is somewhat of a departure from the spirit of the earlier tests. In line with this opinion, the Wire Test Committee has agreed that no material for test shall be purchased in the open market. The lack of complete information concerning the method of preparation of such samples and the very good chance that they will not fall accurately into the classes of materials, coating weights, etc., selected by the Wire Test Committee would make such samples of much less value than those specially prepared for these tests.

The following kinds of materials will be tested:

1. Uncoated wire and fencing (both copper-bearing and non-copper-bearing).
2. Galvanized wire and fencing (any galvanizing process permitted).
3. Stainless steel wire and fencing.
4. Copper-weld wire and fencing.
5. Lead-clad wire and fencing.
6. Dichromate-treated wire (unfabricated). This process has recently been developed to improve the serviceability of galvanized coatings which are not bent in service.

Only the unfabricated (plain) wire samples will be returned to a central testing laboratory for determination of progressive changes in the physical properties of the wire as weathering continues. The fencing and barbed wire samples will be inspected at the test sites for general appearance, spread of rusting, etc.

As detailed in the Appendix, the methods of collecting, testing, marking, and shipping of the samples to the test sites have been so designed that the identity of the producer of a particular sample shall always remain unknown. The Wire Test Committee has agreed that all records pertaining to the source of supply of test materials shall be destroyed as soon as the erection of samples has been satisfactorily completed and all data have been obtained on the original chemical and physical properties of the materials undergoing test. The Wire Test Committee feels this step is essential to the success of the tests, since they are designed to yield data evaluating only such factors as kind and weight of coating, composition of base metal, gage of wire, etc. By so doing, the Wire Test Committee specifically avoids the testing of commercial brands of fabricated wire products.

In line with the above method of conducting the tests, the Wire Test Committee recommends that the following statement shall be made in this report and in all subsequent reports where reference is made to the samples of wire and wire products under exposure tests:

> "It is emphasized that the weight of coating ranges shown under each weight group have been arbitrarily chosen and purposely held to close limitations by the committee and do not necessarily individually represent any manufacturer's commercial product. On the other hand, the entire range of coatings covered by all weight groups as a whole are designed to include a sufficient range of coating weight to furnish the useful corrosion resistance data desired."

Wherever possible, a wide range of weights of coating for each type of product has been provided, running from 0.2 oz. per sq. ft. of uncoated wire surface to 1.6+ oz. per sq. ft., where such weights are available. Such a broad range of weights of coating should furnish sufficient information to permit the selection of the most economical weight of coating for a given service condition.

It was decided that no particular end point should be sought in determining the serviceability of test specimens. It was felt that a rather complete picture of the deterioration of the samples, including extent of rusting, change in physical properties, and decrease of cross-section of wires, would furnish information suitable for analysis by experts interested in predicting serviceability of a variety of products.

It is agreed that the gage of all products with the exception of chain-link fence shall be the gage of the finished galvanized wire and that tensile strength shall be calculated from this gage. In the case of chain-link fencing, the bare wire shall be full gage as specified. The above is in accordance with commercial practice.

The number of types of galvanized wire products included in the test have been reduced to farm-field fencing, barbed wire, chain-link fencing, strand and plain wire. A further reduction in the number of exposure samples has been made by arbitrarily eliminating the variable of several different base materials in each weight of coating class. The exposure of plain wire samples in several gages with a wide range of weights of coatings in each gage has been added to the test.

The Wire Test Committee has given a great deal of thought to the size and number of test specimens, methods for erection, inspection (both in the field and at a central testing laboratory) and number of suppliers submitting samples in each type and weight of coating class. The program outlined in the Appendix provides for the maximum number and sizes of specimens the committee feels it will be able to care for properly. The limits have been set with regard to the money available for tests, test space required, time necessary for proper inspections, etc. After a more detailed analysis of costs, it may appear desirable to restrict still further the number of samples representing each class of materials.

In line with the policy of placing emphasis on the testing of classes of material, gage of wire, weight of coating, etc., rather than the testing of commercial brands, the Wire Test Committee has adopted the following procedure in selecting materials for test submitted by various suppliers. This procedure is to be followed in all cases where the number of suppliers submitting materials of a given type and weight of coating class exceeds the number permitted by existing test rack facilities:

The collector of samples shall arbitrarily select, in accordance with the schedule of the number of suppliers whose materials can be accommodated on the test racks (as given in the Appendix), those materials showing the widest possible range of types of coatings possible in each class. To illustrate: if five suppliers submit materials in a class now limited to three suppliers, and if, of the five, three furnish ordinary hot-dipped coatings, one, electroplated coatings, and one, sherardized coatings, the collector will arbitrarily select materials from one supplier of hot-dipped coatings, automatically including the electroplated and sherardized products.

Three of the previous test sites and six new test sites have been selected, as shown in the Appendix, in order to give a wide range of exposure conditions. Definite offers of cooperation have been received from the several agricultural colleges at which materials are to be exposed and a very active interest in the whole project has been evinced.

The election of a chairman for the ensuing term of two years resulted in the re-election of the present incumbent.

This report of Subcommittee VIII has been submitted to letter ballot of the subcommittee which consists of 39 members; 28 members returned their ballots, of whom 27 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the subcommittee,

R. F. PASSANO,
Chairman.

APPENDIX

WIRE TEST PROGRAM

TEST MATERIALS

The following materials have been selected for exposure to atmospheric corrosion:

Farm-Field Fencing	Barbed Wire
Plain Wire	Wire Strand
Chain-Link Fence	

Farm-Field Fencing:

All samples to be of standard hinge-joint type fence only, 39 in. in height with 6 in. stay spacing. Each sample is to be long enough to provide a test length of 16½ ft. after erection. All line and stay wires of the same gage and weight of coating of each sample of fencing shall be made of material from the same bundle of wire. In erecting, care shall be taken that the approximate tension specified by the manufacturer shall be applied. The original breaking strength of each line and stay wire shall be determined. Base metal of the wire composing this fence to be basic open-hearth, copper-bearing steel containing 0.20 to 0.25 per cent copper and 0.08 to 0.20 per cent carbon.

Four types of galvanized fencing are to be submitted to the following specifications:

Type	Gage[a] of Top and Bottom Line Wire	Gage[a] of Intermediate Line Wires and Stay Wires
1	No. 9	No. 9
2	No. 9	No. 11
3	No. 10	No. 12½
4	No. 11	No. 14½

---

[a] Steel wire gage.

The farm-fence samples have been classified as to types and weights of coating as follows:

Class	Type of Fence	Weight of Coating, oz. per sq. ft. of uncoated wire surface
1 (Bare)	1, 2, 3 and 4	0.0
2	3 and 4	0.20 to 0.30
2	1 and 2	0.25 to 0.35
3	3 and 4	0.35 to 0.45
3	1 and 2	0.45 to 0.55
4	3 and 4	0.50 to 0.60
4	1 and 2	0.60 to 0.70
5	3 and 4	0.70 to 0.85
5	1 and 2	0.80 to 1.00
6	1 and 2	1.6 to 1.8

Every wire in a sample of fencing, whether stay or line wire, is to carry the weights of coating designated in each class. The bare wire fence samples shall be bright, lime drawn and lead annealed in such a manner that the resultant physical properties of the wire shall approximate those of the galvanized samples; the bare wire samples shall be selected from the same coils of wire used in the manufacture of the galvanized fence samples. The non-copper-bearing wires shall be processed in the same manner. The wire shall not be coated with any substance after drawing.

The Wire Test Committee is authorized to test farm-fence samples carrying weights of coating in excess of 1.8 oz. per sq. ft. of uncoated wire surface if available at the time the tests are started.

The Wire Test Committee is further authorized to test wire and wire products made from stainless steel, or from other ferrous alloys or from steel with protective metallic coatings other than zinc. It was agreed to contact with manufacturers of copper-clad and lead-clad wire fencing to determine whether they would desire to submit farm fence for the proposed tests. The following specific alloys of stainless steel are proposed:

18 per cent chromium, 8 per cent nickel
12 to 14 per cent chromium, 0.12 per cent carbon (max.)
4 to 6 per cent chromium, 0.20 per cent carbon (max.)

The following alternate specifications covering stainless steel wire of the above compositions specifically are proposed:

Type	Gage[a] of Top and Bottom Line Wire, in.				Gage[a] of Intermediate Line and Stay Wire, in.			
	Steel	18 per cent Chromium 8 per cent Nickel	12 to 14 per cent Chromium	4 to 6 per cent Chromium	Steel	18 per cent Chromium 8 per cent Nickel	12 to 14 per cent Chromium	4 to 6 per cent Chromium
1	0.148	0.085	0.105	0.121	0.148	0.085	0.105	0.121
2	0.148	0.085	0.105	0.121	0.121	0.069	0.085	0.098
3	0.135	0.078	0.095	0.110	0.098	0.057	0.070	0.080
4	0.121	0.069	0.085	0.098	0.076	0.044	0.054	0.062

[a] Steel wire gage.

The above specifications are based on reducing the size of the stainless wire in direct proportion to the relative tensile strengths of this wire and commercial farm-fence steel wire. The following tensile strengths were used as a basis of comparison:

	TENSILE STRENGTH, LB. PER SQ. IN.
Steel wire	100 000
18 per cent chromium, 8 per cent nickel	300 000
12 to 14 per cent chromium	200 000
4 to 6 per cent chromium	150 000

Although no detailed specifications covering wire sizes of the 16 to 18 per cent chromium type have been calculated, the Wire Test Committee will accept this material for exposure tests (cooperation of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys has been assured in selecting material and carrying out exposure tests of chromium-iron alloys). The Wire Test Committee has also agreed to expose galvanized wire which has been treated with a dichromate solution. This treatment has recently been developed to increase the serviceability of zinc coatings which are not subjected to bending in service.

TABLE I.—FARM-FIELD FENCING.

Class	Galvanized				Special			
	Weight of Coating	Number of Types	Producers	Total	Material	Number of Types	Producers	Total
1 (Bare)	None .... Copper-bearing.	.. 4	.. 2	.. 8	Stainless, 18 per cent Chromium, 8 per cent Nickel....	2	2	4
2	0.20 to 0.30. 0.25 to 0.35.	4	2	8	Stainless, 16 to 18 per cent Chromium..............	2	2	4
3	0.35 to 0.45. 0.45 to 0.55.	4	4	16	Stainless, 12 to 14 per cent Chromium..............	2	2	4
4	0.50 to 0.60. 0.60 to 0.70.	4	4	16	Stainless, 4 to 6 per cent Chromium..............	2	2	4
5	0.70 to 0.85. 0.80 to 1.00.	4	5	20	Copper Weld No. 1..........	2	1	2
6	1.6 to 1.8.....	2	2	4	Copper Weld No. 2..........	2	1	2
	Total........	....	....	72	Lead Clad No. 1............	2	1	2
					Lead Clad No. 2............	2	1	2
					Total....................	....	....	24
Total Number of Samples........96								

A tentative outline of the number of samples of farm-field fencing to be erected is given in Table I.

NOTE.—In Tables I, III and IV relating to schedules of number of suppliers and samples, the given schedules are not regarded as fixed. They will be determined by the number of suppliers submitting materials in a given class; the limiting factor in each case being the total number of samples which can be accommodated on the test racks.

Plain Wire:

The straight (unfabricated) wire samples are to be Nos. 6, 9, 11, 12½ and 14½ gage wire. The base metal is to be both non-copper-bearing and copper-bearing, the composition to be the same as specified under "Farm-Field Fencing." The specifications as to weights of zinc coating and those covering composition and gages of stainless steel and steel or other ferrous alloys with protective metallic coatings are the same as those given for "Farm-Field Fencing."

TABLE II.—PLAIN WIRE.

NOTE.—The ✓ mark indicates that only material of this description will be included in the tests.

STRAIGHT WIRES

Gage (Steel Wire Gage)	Weight of Coating, oz. per sq. ft. of uncoated wire surface										
	Bare		0.20 to 0.30	0.25 to 0.35	0.35 to 0.45	0.45 to 0.55	0.50 to 0.60	0.60 to 0.70	0.70 to 0.85	0.80 to 1.00	1.6 to 1.8
	Non-Copper-Bearing	Copper-Bearing									
6	✓	✓		✓		✓		✓		✓	✓
9	✓	✓		✓		✓		✓		✓	✓
11	✓	✓		✓		✓		✓		✓	✓
12½	✓	✓	✓		✓		✓		✓		✓
14½	✓	✓	✓		✓		✓		✓		✓
9[a]										✓	
12½[a]									✓		

Weight of Coating, oz. per sq. ft. of uncoated wire surface,	Number of Gages	Copper and Non-Copper-Bearing	Producers	Total
Bare	5	2	2	20
0.20 to 0.30	2	1	3	6
0.25 to 0.35	3	1	3	9
0.35 to 0.45	2	1	3	6
0.45 to 0.55	3	1	5	15
0.50 to 0.60	2	1	5	10
0.60 to 0.70	3	1	5	15
0.70 to 0.85	2	1	5	10
0.80 to 1.00	3	1	5	15
1.6 to 1.8	5	1	2	10
Zinc-coated and chromated	2	1	1	2
Total Number of Bare and Galvanized Samples				118

SPECIAL WIRE SAMPLES

Stainless				Copper Weld		Lead Clad	
18 per cent Chromium, 8 per cent Nickel	16 to 18 per cent Chromium	12 to 14 per cent Chromium	4 to 6 per cent Chromium	No. 1	No. 2	No. 1	No. 2
✓(0.085)[b] ✓(0.078)[b] ✓(0.057)[b]	✓( )[c] ✓( )[c] ✓( )[c]	✓(0.105)[c] ✓(0.095)[c] ✓(0.070)[c]	✓(0.121)[c] ✓(0.110)[c] ✓(0.080)[c]	✓( )[c] ✓( )[c] ✓( )[c]	✓( )[c] ✓( )[c] ✓( )[c]	✓( )[c] ✓( )[c] ✓( )[c]	✓( )[c] ✓( )[c] ✓( )[c]
Total Stainless Samples.......................... 12				Total Copper Weld Samples, 6		Total Lead Clad Samples, 6	
Total Number of Samples of Plain Wire.......... 142							

[a] Zinc-coated and chromated.
[b] Diameters of wire samples.
[c] Diameters of these samples not yet determined.

A tentative outline of the number of straight wire samples to be erected is given in Table II.

Barbed Wire:

Barbed wire is to be all No. 12½ gage line wire, No. 14 gage-4-point barb hog wire. The test samples shall be 16½ ft. in length and shall be erected on standard barbed wire supports such that the various weights of coating of the barbed wire samples shall be placed above the same weights of coating carried by the farm-fence samples, the base metal of the barbed wire samples to be the same as that specified in "Farm-Field Fencing."

The barbed wire samples have been classified as to weights of coating as follows:

CLASS	WEIGHT OF COATING, OZ. PER SQ. FT. OF UNCOATED WIRE SURFACE
1 (Bare)	0.0
2	0.20 to 0.30
3	0.35 to 0.45
4	0.50 to 0.60
5	0.70 to 0.85
6 (with alternate barbs)	0.85 to 1.0
7	galvanized after, or coatings in excess of 1.6, minimum

A tentative outline of the number of barbed wire samples to be erected is given in Table III.

TABLE III.—BARBED WIRE.

CLASS	WEIGHT OF COATING, OZ. PER SQ. FT. OF UNCOATED WIRE SURFACE	PRODUCERS	NUMBER OF SAMPLES
1	Bare	2	2
2	0.20 to 0.30	2	2
3	0.35 to 0.45	5	5
4	0.50 to 0.60	5	5
5	0.70 to 0.85	5	5
6	0.85 to 1.0 (with alternate barbs)	5	5
7	galvanized after, or coatings in excess of 1.6, minimum	3	3
	Total Number of Samples		27

Wire Strand:

All samples of wire strand shall be ⅜ in. in diameter and shall be composed of 7 wires, each 0.120 in. in diameter. The steel shall be of the grade known as Siemens-Martin according to the Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Wire Strand (Cable) (A.S.T.M. Designation: A 122) of the American Society for Testing Materials.[1] The analysis of the strand will not be specified as to base metal (whether copper or non-copper-bearing), although if a manufacturer should submit a non-copper-bearing sample such material should have a maximum copper content of 0.06 per cent and have approximately the same chemical composition otherwise as the copper-bearing steel wire submitted by him.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 297.

The wire strand samples have been classified as to weights of coating as follows:

CLASS	WEIGHT OF COATING, OZ. PER SQ. FT. OF UNCOATED WIRE SURFACE
1	0.80 to 0.95
2	1.0 to 1.2
3	1.3 to 1.5
4	1.6 to 1.8
5	2.4 to 2.6

A tentative outline of the number of wire strand samples to be erected is given in Table IV.

TABLE IV.—WIRE STRAND.

CLASS	WEIGHT OF COATING, OZ. PER SQ. FT. OF UNCOATED WIRE SURFACE	PRODUCERS	NUMBER OF SAMPLES
1	0.80 to 0.95	4	4
2	1.0 to 1.2	3	3
3	1.3 to 1.5	2	2
4	1.6 to 1.8	2	2
5	2.4 to 2.6	2	2
	Total Number of Samples		13

Chain-Link Fence:

All samples of chain-link fence to be 6 ft. in height with 2-in. mesh in two gage sizes Nos. 9 and 6. Each sample shall be 16½ ft. in length erected at ground level at proper tension with regular posts, braces, etc.

The chain-link fence samples have been classified as to weights of coating and gage sizes as follows:

CLASS	GAGE[a]	WEIGHT OF COATING, OZ. PER SQ. FT. OF UNCOATED WIRE SURFACE
1	No. 9	under 0.50
2	No. 6 and No. 9	1.20 to 1.50
3	No. 9	2.4 to 3.0

---

[a] Steel wire gage.

The number of samples of chain-link fence to be erected has not yet been decided.

TEST LOCATIONS

The test locations and the types of products which will be tested at each location are shown in Table V.

TESTING DETAILS

The following detail tests are to be made on all material as received:

Base Metal:

1. *Chemical Analysis.*—Determinations of carbon, manganese, phosphorus, sulfur, silicon, copper, nickel, molybdenum and chromium.
2. *Physical Tests.*—Determinations of tensile strength and percentage elongation in 10 in. (Average of three determinations).

Zinc Coatings:

1. Determination of microstructure.
2. Weight of coating.
3. Wrap test.
4. Uniformity of coating.

TABLE V.—TEST LOCATIONS.

NOTE.—The ✓ mark indicates that only those materials checked at each location will be exposed at that test site.

NAME	FARM-FENCE AND BARBED WIRE	STRAIGHT WIRE	WIRE STRAND	CHAIN-LINK FENCE
State College, Pa.	✓	✓	✓	
Lafayette, Ind. (Purdue University)	✓	✓	✓	✓
College Station, Tex. (The Agricul. and Mech. College of Texas)	✓	✓	✓	
Ames, Iowa (Iowa State College)	✓	✓	✓	
Ithaca, N. Y. (Cornell University)	✓	✓	✓	✓
Pittsburgh, Pa.		✓	✓	✓
Sandy Hook, N. J.		✓	✓	✓
Bridgeport, Conn.		✓	✓	✓
Manhattan, Kans.	✓			

Suppliers of materials for these tests shall submit to the collector of samples chemical and physical test data on their materials in line with the above. In case of pertinent disagreement between tests made by the Wire Test Committee and by the producer, retests to correlate results shall be made before the material under question is accepted for exposure. All tests shall be made in accordance with standard methods adopted by the Wire Test Committee.

A sub-subcommittee has been appointed consisting of Mr. W. H. Finkeldey, chairman, and Messrs. F. M. Crapo, F. C. Elder, C. A. Kellogg and L. H. Winkler to determine and specify the detailed procedure to be used in recording microstructure of zinc coatings and of the base metals. This will include recommendations with respect to etching reagent and magnification. The same committee was also charged with the work of recommending a technique of photographing the wrap tests for the purpose of record. It has been agreed that wrap tests would be conducted around a mandrel having a diameter equal to the diameter of the wire under test.

A sub-subcommittee composed of Mr. W. H. Finkeldey, chairman, and Mr. C. C. Crane has been charged with the work of outlining standard methods of determining weight of coating. Determinations will be made of iron, zinc (by difference), lead and cadmium.

COLLECTION AND DISTRIBUTION OF SAMPLES

In general, the principal features of the plan for the collection and distribution of the samples include the following:

1. The shipment of test materials to one central collecting point where they will be sampled, marked for identification and held in storage until all test samples are ready for shipment to the field locations.

2. The appointment by Mr. C. L. Warwick of a collector of samples to supervise and handle all the details in connection with the receipt, sampling and marking of the test samples.

3. The Wire Test Committee in charge of exposure tests of Subcommittee VIII will furnish to Mr. Warwick and the collector of samples a full description of all the types of material and amounts to be submitted by each manufacturer. They will also furnish Mr. Warwick and the collector of samples a detailed plan covering the cutting up, sampling and marking of all the individual test specimens and full directions for shipping these to the various test locations. The A.S.T.M. will furnish the manufacturers supplying samples with regular purchase (no-charge) orders covering the test material so that the preparation of the samples can be handled in the regular routine manner in the manufacturer's plant.

4. The collector of samples appointed by Mr. Warwick will also direct and supervise the erection of the samples at the various test locations.

ERECTION OF SAMPLES

The detail drawings accompanying this report, Figs. 1, 2 and 3, give the necessary information on the erection of the following products:

1. *Farm-Field Fence Test.*—The farm-fence test comprises essentially the construction of eleven rows of fence spaced 6 ft. apart, each row consisting of ten 16½-ft. test specimens. This layout plus the space required by the wire and strand test will necessitate a plot

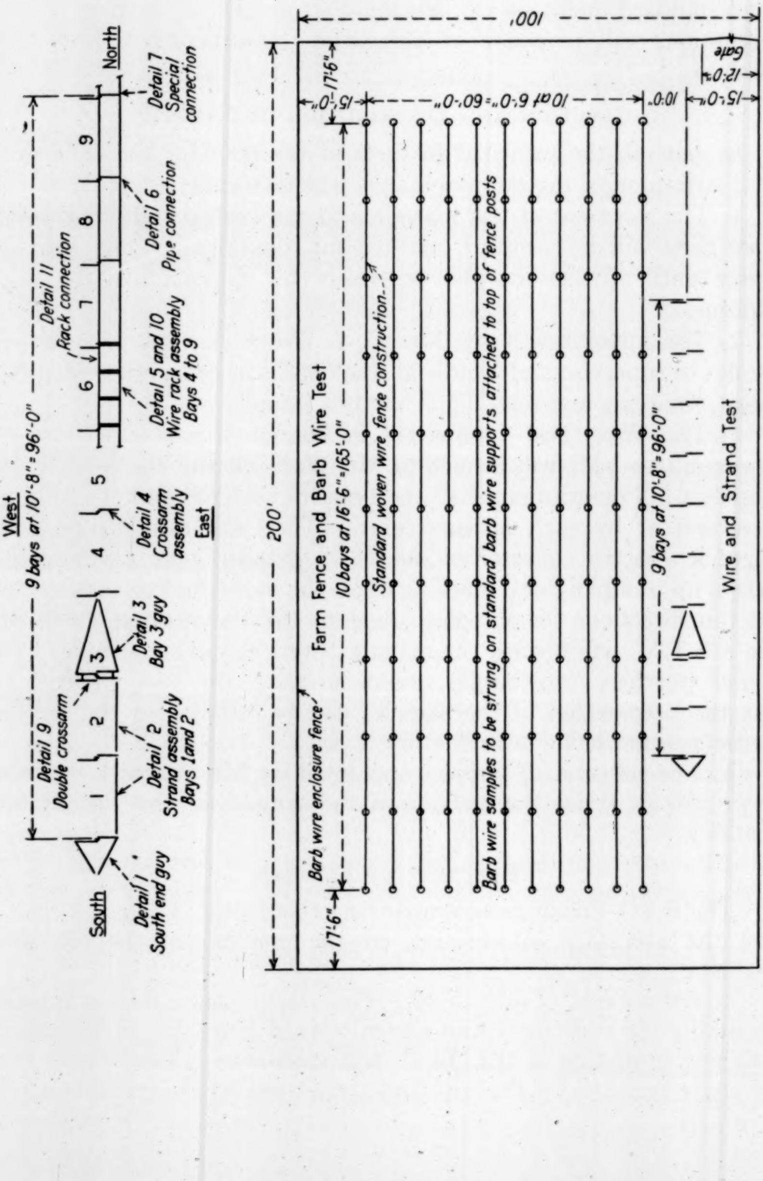

West
9 bays at 10'-8" = 96'-0"
South
Detail 1 South end guy
Detail 9 Double crossarm
Detail 2 Strand assembly Bays 1 and 2
Detail 3 Bay 3 guy
Detail 4 Crossarm assembly
East
Detail 5 and 10 Wire rack assembly Bays 4 to 9
Detail 11 Rack connection
Detail 6 Pipe connection
Detail 7 Special connection
North
1
2
3
4
5
6
7
8
9
100'
200'
17'-6"
17'-6"
15'-0"
10 at 6'-0" = 60'-0"
10'-0"
15'-0"
12'-0"
Gate
Barb wire enclosure fence
Farm Fence and Barb Wire Test
10 bays at 16'-6" = 165'-0"
Standard woven wire fence construction
Barb wire samples to be strung on standard barb wire supports attached to top of fence posts
9 bays at 10'-8" = 96'-0"
Wire and Strand Test

FIG. 1.—Erection Diagram of Racks at Each Test Location.

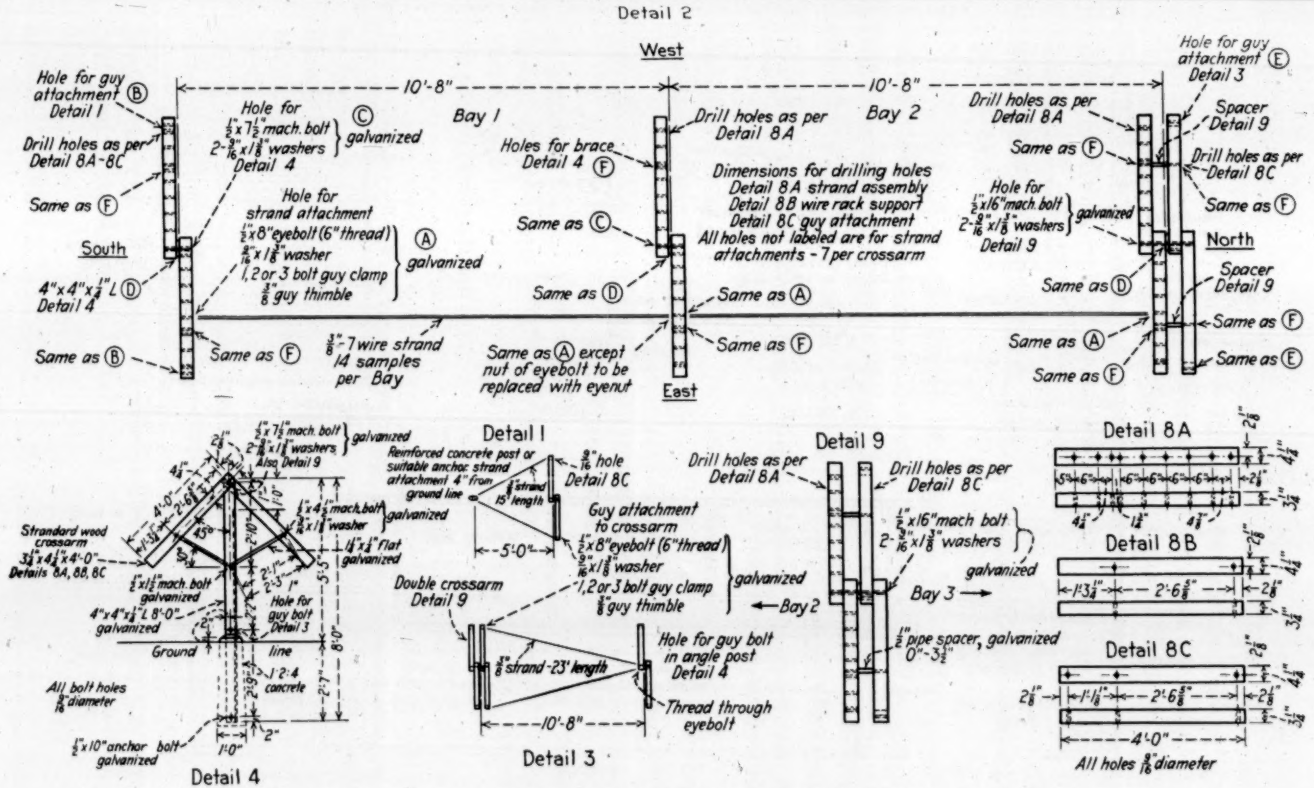

Detail 2
West
East
South
North
10'-8"
Bay 1
Bay 2
Hole for guy attachment (B) Detail 1
Drill holes as per Detail 8A-8C
Same as (F)
4"x4"x1/4" L (D) Detail 4
Same as (B)
Hole for 1/2"x7 1/2" mach. bolt 2-9/16"x1 3/8" washers Detail 4 (C) galvanized
Hole for strand attachment 1/2"x8" eyebolt (6" thread) 9/16"x1 3/8" washer 1,2 or 3 bolt guy clamp 3/8" guy thimble (A) galvanized
Same as (F)
3/8"-7 wire strand 14 samples per Bay
Holes for brace Detail 4 (F)
Same as (C)
Same as (D)
Same as (A) except nut of eyebolt to be replaced with eyenut
Drill holes as per Detail 8A
Same as (A)
Same as (F)
Dimensions for drilling holes
Detail 8A strand assembly
Detail 8B wire rack support
Detail 8C guy attachment
All holes not labeled are for strand attachments - 7 per crossarm
Drill holes as per Detail 8A
Same as (F)
Hole for 1/2"x16" mach. bolt 2-9/16"x1 3/8" washers Detail 9 galvanized
Same as (D)
Same as (A)
Same as (F)
Hole for guy attachment (E) Detail 3
Spacer Detail 9
Drill holes as per Detail 8C
Same as (F)
Spacer Detail 9
Same as (F)
Same as (E)
2 5/8"
4 1/4"
4'-0"
2'-6 1/2"
1'-3 3/4"
45°
1/2"x7 1/2" mach. bolt 2-9/16"x1 3/8" washers Also Detail 9 galvanized
1'-0"
1/2"x4 1/2" mach. bolt 3/8"x1 3/8" washer galvanized
1 1/4"x1/4" flat galvanized
2'-10"
2'-1"
2'-3"
1"
5'-5"
2'-2"
Hole for guy bolt Detail 3
8'-0"
Standard wood crossarm 3 1/4"x4 1/4"x4'-0" Details 8A, 8B, 8C
1/2"x1 1/2" mach. bolt galvanized
4"x4"x1/4" L 8'-0" galvanized
Ground line
1:2:4 concrete
2'-9"
2'-7"
All bolt holes 9/16" diameter
1/2"x10" anchor bolt galvanized
1'-0"
2"
Detail 4
Detail 1
Reinforced concrete post or suitable anchor strand attachment 4" from ground line
9/16" hole Detail 8C
3/8" strand 15' length
5'-0"
Guy attachment to crossarm 1/2"x8" eyebolt (6" thread) 9/16"x1 3/8" washer 1,2 or 3 bolt guy clamp 3/8" guy thimble galvanized
Double crossarm Detail 9
3/8" strand-23' length
Hole for guy bolt in angle post Detail 4
Thread through eyebolt
10'-8"
Detail 3
Detail 9
Drill holes as per Detail 8A
Drill holes as per Detail 8C
1/2"x16" mach. bolt 2-9/16"x1 3/8" washers galvanized
Bay 3 →
← Bay 2
1/2" pipe spacer, galvanized 0'-3 1/2"
Detail 8A
5 1/4" 6" 6" 6" 6" 6"
4 1/4"
1 1/2"
4 3/8"
2 1/8"
2 5/8"
4 1/4"
3 1/4"
Detail 8B
1'-3 3/4"
2'-6 5/8"
2 1/8"
Detail 8C
2 1/8"
1'-1 1/8"
2'-6 5/8"
4'-0"
All holes 9/16" diameter

FIG. 2.—Details and Assembly of Racks at Each Test Location.

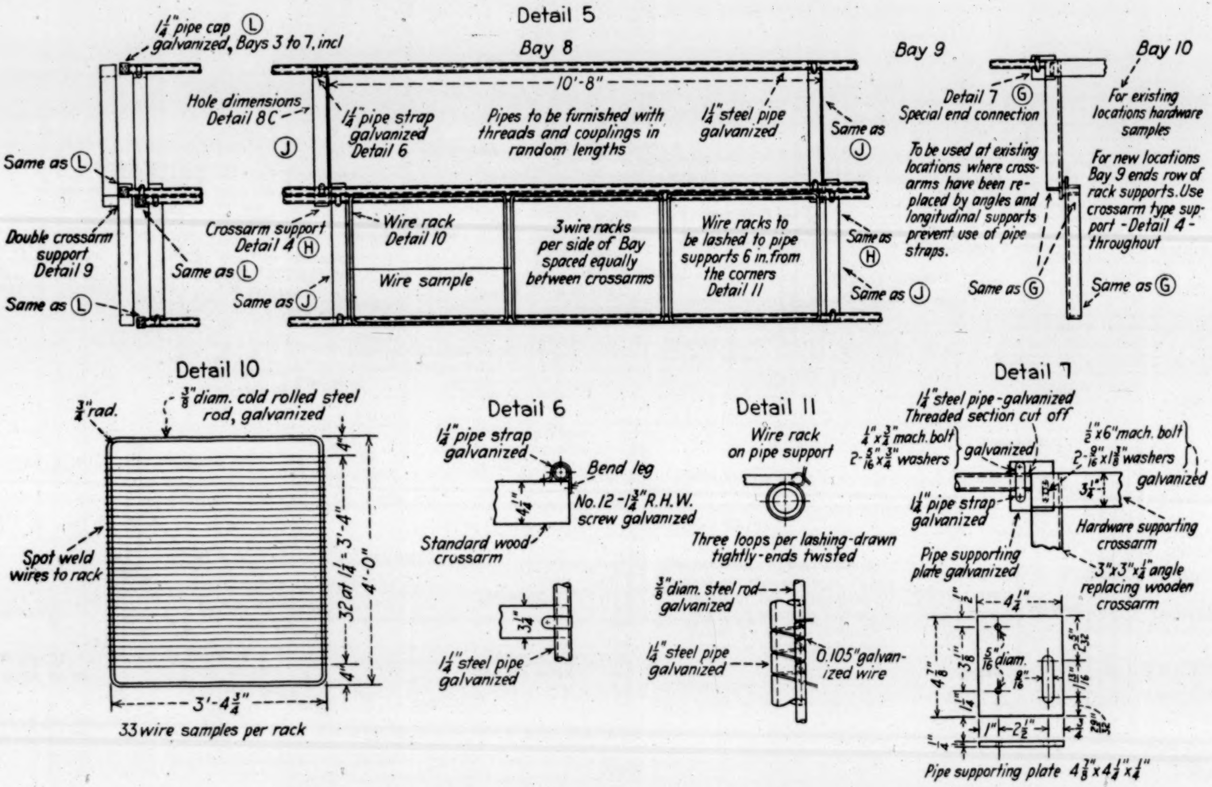

Detail 5
Bay 8
Bay 9
Bay 10
1¼" pipe cap Ⓛ galvanized, Bays 3 to 7, incl
Hole dimensions Detail 8C
Ⓙ
Same as Ⓛ
Double crossarm support Detail 9
Same as Ⓛ
Same as Ⓛ
10'-8"
1¼" pipe strap galvanized Detail 6
Pipes to be furnished with threads and couplings in random lengths
1¼" steel pipe galvanized
Same as Ⓙ
Crossarm support Detail 4 Ⓗ
Wire rack Detail 10
Wire sample
Same as Ⓙ
3 wire racks per side of Bay spaced equally between crossarms
Wire racks to be lashed to pipe supports 6 in. from the corners Detail 11
Same as Ⓗ
Same as Ⓙ
Detail 7 Ⓖ Special end connection
To be used at existing locations where crossarms have been replaced by angles and longitudinal supports prevent use of pipe straps.
Same as Ⓖ
For existing locations hardware samples
For new locations Bay 9 ends row of rack supports. Use crossarm type support - Detail 4 - throughout
Same as Ⓖ
Detail 10
¾" rad.
⅜" diam. cold rolled steel rod, galvanized
4"
32 at 1¼" = 3'-4"
4'-0"
4"
Spot weld wires to rack
3'-4¾"
33 wire samples per rack
Detail 6
1¼" pipe strap galvanized
Bend leg
4¼"
No. 12 - 1¾" R.H.W. screw galvanized
Standard wood crossarm
3¼"
1¼" steel pipe galvanized
Detail 11
Wire rack on pipe support
Three loops per lashing-drawn tightly-ends twisted
⅜" diam. steel rod galvanized
1¼" steel pipe galvanized
0.105" galvanized wire
Detail 7
1¼" steel pipe - galvanized Threaded section cut off
¼" x ¾" mach. bolt
2 - 5/16" x ¾" washers
galvanized
½" x 6" mach. bolt
2 - 9/16" x 1⅜" washers
galvanized
3¼"
1¼" pipe strap galvanized
Pipe supporting plate galvanized
Hardware supporting crossarm
3" x 3" x ¼" angle replacing wooden crossarm
4¼"
4⅞"
3⅛"
1¼"
5/16" diam.
9/16"
2 5/32"
1 13/16"
1"
2½"
¼"
Pipe supporting plate 4⅞" x 4¼" x ¼"

FIG. 3.—Details and Assembly of Racks at Each Test Location.

of ground 200 by 100 ft. In so far as possible, the farm fence will be erected in accordance with standard practice.

2. *Wire and Strand Test.*—This test will require nine bays of cross-arm supports, two of which will be used for the strand test. At the new locations this row of cross-arm supports will be erected 10 ft. from the last row of farm-field fence. In order that the strand and plain wire samples may be exposed with minimum effort and expense, the existing test bays at the old locations have been utilized and the same construction with slight modifications will be used at the new locations. (See Figs. 2 and 3, details Nos. 1, 3, 4, 6, 7, 8B, 8C and 9.)

The strand samples are to be spaced 6 in. apart. Sufficient strand shall be provided so that each sample can be cut in two, one-half to be exposed on each side of a bay. (See Fig. 2, details Nos. 2 and 8A.)

The plain-wire samples are to be mounted on individual racks supported by pipe running longitudinally along the cross-arm supports. Each rack holds 33 samples spaced at $1\frac{1}{4}$-in. intervals. Each bay holds 6 racks, 3 per side. (See Fig. 3, details Nos. 5, 10 and 11.) A shipping container holding 5 or 6 racks will be designed in order to facilitate the return of a complete set of test samples to some central point for inspection at appropriate intervals.

3. *Barbed Wire Test.*—The barbed wire samples are to be strung on standard barbed wire supports attached to the top of the fence posts. The various weights of coating carried by the barbed wire samples will be placed above the same weights of coating carried by the corresponding fence sample.

4. *Chain-Link Fence Test.*—The chain-link fence will be of standard construction and will be erected at the existing locations in the space originally planned for testing the farm-field fence. It will be necessary to remove the old posts now in place at these locations (Sandy Hook, N. J., and Pittsburgh, Pa.). At the three new locations the chain-link fence samples will be erected in the following manner. At Cornell University and at Purdue the fence will parallel the wire and strand test set up at a distance of 10 ft. If the number of specimens submitted necessitates the erection of more than one row, some slight additional width of test plot will be required. At Bridgeport, Conn., the chain-link fence samples will be exposed in the present test yard of the American Chain Corp.

REPORT OF SUBCOMMITTEE X ON EMBRITTLEMENT INVESTIGATION

In 1932, Subcommittee X on Embrittlement Investigation completed the major portion of its assignment in reporting the research on embrittlement of galvanized structural steel[1] made at Battelle Memorial Institute, and in preparing the Tentative Recommended Practice for Safeguarding Against Embrittlement of Hot-Galvanized Structural Steel Products and Procedure for Detecting Embrittlement (A 143 - 32 T).[2]

Following the publication of this report several points were raised on which it was felt that additional information should be obtained while the recommended practice was still tentative and before it was adopted as standard by the Society. Mr. A. B. Campbell of the Edison Electric Institute was appointed to gather information on the following details:

1. On the freedom of the intermediate sizes of shapes from injurious embrittlement;
2. On the susceptibility to serious embrittlement of other open-hearth steels;
3. On the necessity for reducing the gage length for testing intermediate shapes with small holes; and
4. On the necessity for measuring reduction in thickness in testing angles.

This work is in progress, but as very few tower lines have been built during the past two years, it has been impossible to collect any large amount of data. It therefore seems expedient that some further time should be allowed for the accumulation of an adequate and representative amount of information.

Mr. W. G. Kelley was appointed chairman of a subcommittee to collect data on the procedure for detecting injurious embrittlement of cold-worked steel plates and bars and their products, commonly called hardware. A survey was made among the various producers and users of this type of material, commonly known as pole line hardware, and the experience gathered from the questionnaire seems to show that very little trouble is being experienced from injurious embrittlement in this type of material. Provided open-hearth steel is used, and proper annealing or stress relieving operations are carried out as proposed in the report on the embrittlement investigation,[1] the possibility of injurious embrittlement is remote. The fabricator should satisfy himself as to the quality of the steel and the manufacturing processes to insure good results in the finished product. If proper care is taken in the selection of steel and in manufacture, this should give assurance of comparative freedom from embrittlement in pole line hardware. No simple means for the detection of embrittlement has been developed by the users of this type of material other than testing to destruction. The present tendency among manufacturers appears to be to extend the process of working the steel hot into somewhat smaller shapes and sizes than those covered by the recommended practice of the committee. In general, there has been a rather limited amount of trouble from embrittlement in pole line hardware; and that which has been encountered may all be traced to the use of improper steel or improper manufacturing processes.

---

[1] Samuel Epstein, "Embrittlement of Hot-Galvanized Structural Steel," *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 293 (1932).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 615 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 136.

Respectfully submitted on behalf of the subcommittee,

W. G. KELLEY,
Chairman.

---

[1] Samuel Epstein, "Embrittlement of Hot-Galvanized Structural Steel," *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 293 (1932).

REPORT OF COMMITTEE A-6
ON
MAGNETIC PROPERTIES

Committee A-6 on Magnetic Properties held one meeting during the year, on March 8, 1934, in Washington, D. C., in conjunction with the Spring Group Meetings of A.S.T.M. Committees.

The National Electrical Manufacturers Association is now represented on Committee A-6 by Mr. P. H. Dike.

The Tentative Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing (A 127 – 31 T)[1] were revised in March by Subcommittee I on Definitions and Nomenclature (W. J. Shackelton, chairman) and subsequently approved by Committee A-6 and by Committee E-8 on Nomenclature and Definitions. The definitions in their revised form are appended hereto.[2] These definitions now agree, in so far as possible, with the definitions on magnetics included in the proposed American Standard that has been prepared by the Sectional Committee on Definitions of Electrical Terms, functioning under the procedure of the American Standards Association. In view of the fact that the definitions will be used not only by scientists and engineers but also by non-technically trained men, it was thought essential to modify and amplify some of them. It is believed that there is no serious conflict between them and the definitions developed by the sectional committee. The committee therefore believes that these revised definitions as appended hereto[2] should be adopted as standard and accordingly recommends that they be approved for reference to letter ballot of the Society for adoption. This recommendation has been referred to letter ballot of the committee, which consists of 16 members; 12 members returned their ballots, all of whom voted affirmatively.

The completely revised Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 33), which include the alternating current tests at low induction, were adopted as standard in 1933. This completed the major part of the work of Subcommittee II on Alternating Current Tests at Low Induction (R. L. Sanford, chairman). Instrument manufacturers are now preparing commercial designs, of the bridge type, which will doubtless be put on the market very soon.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 696 (1931); also 1933 Book of A.S.T.M. Tentative Standards, p. 182.

[2] The revised definitions appear in the 1934 Supplement to Book of A.S.T.M. Standards, p. 69.—Ed.

Subcommittee III on Tests at High Magnetizing Forces (L. E. Howard, chairman) has been unable to hold a meeting during the year and therefore has little to report. Mr. F. P. Fahy has developed a modification of his high magnetization adapter which it is expected he will submit soon to the committee for consideration.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee, which consists of 16 members; 12 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

THOMAS SPOONER,
Chairman.

R. L. SANFORD,
Secretary.

EDITORIAL NOTE

The Tentative Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing, as revised, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, page 69.

REPORT OF COMMITTEE A-9
ON
FERRO-ALLOYS

Committee A-9 on Ferro-Alloys has held one meeting during the past year and plans to meet again prior to the presentation of this report to the Society.

The use of tungsten powder to add tungsten to steels has become obsolete primarily due to the passing of the crucible method of melting, all manufacturers of tungsten steels by the electric-furnace process using either tungsten ore or ferrotungsten. The introduction of sintered alloys containing either metallic tungsten or tungsten carbide demanded the use of a tungsten powder far greater in purity than that required in the Standard Specifications for Tungsten Powder (A 97 – 27). In view of this the committee is recommending the withdrawal of these specifications.

The committee plans to devote itself in the immediate future to consideration of specifications for ferrophosphorus and ferrotitanium, with the possibility that they will also consider a specification for metallic nickel to be used in the manufacture of alloy steels.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Standard.—The committee recommends that the proposed Tentative Method of Sampling Molybdenum Salts and Compounds for Metallurgical Use, as appended hereto,[1] be accepted for publication as tentative.

II. Adoption of Tentative Standards as Standard.—The committee recommends the adoption as standard of the following tentative specifications and methods of test:

Tentative Specifications for Ferromolybdenum (A 132 – 31 T)[2]
Tentative Specifications for Ferrotungsten (A 144 – 32 T)[3]
Tentative Specifications for Low-Carbon Ferromolybdenum (A 145 – 32 T)[3]
Tentative Specifications for Molybdenum Salts and Compounds (A 146 – 32 T)[4]
Tentative Methods of Chemical Analysis of Ferrotungsten and Ferromolybdenum (A 104 – 32 T),[4] to be added to the Standard Methods of Chemical Analysis of Ferro-Alloys (A 104 – 27)

---

[1] See p. 660.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 694 (1931); also 1933 Book of A.S.T.M. Tentative Standards, p. 166.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 636, 638 (1932); also 1933 Book of A.S.T.M. Tentative Standards, pp. 170, 168.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 640, 641 (1932); also 1933 Book of A.S.T.M. Tentative Standards, pp. 172, 173.

III. Withdrawal of Standard.—As mentioned earlier in the report, the committee recommends the withdrawal of the Standard Specifications for Tungsten Powder (A 97 – 27).[1]

The above recommendations have been submitted to letter ballot of the committee, which consists of 28 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Method of Sampling Molybdenum Salts and Compounds for Metallurgical Use	14	0	14
II. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Tentative Specifications for Ferromolybdenum (A 132 – 31 T)	13	0	15
Tentative Specifications for Ferrotungsten (A 144 – 32 T)	13	0	15
Tentative Specifications for Low-Carbon Ferromolybdenum (A 145 – 32 T)	13	0	15
Tentative Specifications for Molybdenum Salts and Compounds (A 146 – 32 T)	13	0	15
Tentative Methods of Chemical Analysis of Ferrotungsten and Ferromolybdenum (A 104 – 32 T)	13	0	15
III. WITHDRAWAL OF STANDARD			
Standard Specifications for Tungsten Powder (A 97 – 27)	10	1	17

The election of officers for the ensuing term of two years resulted in the selection of Charles McKnight, chairman; W. R. Shimer, vice-chairman; and J. J. Crowe, secretary.

This report has been submitted to letter ballot of the committee, which consists of 28 members; 21 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

J. B. GILL,
Chairman.

CHARLES MCKNIGHT,
Secretary.

EDITORIAL NOTE

The proposed Tentative Method of Sampling Molybdenum Salts and Compounds for Metallurgical Use was accepted for publication as tentative and appears on page 660.

The Tentative Specifications for Ferromolybdenum, for Ferrotungsten, for Low-Carbon Ferromolybdenum, for Molybdenum Salts and Compounds, and the Tentative Methods of Chemical Analysis of Ferrotungsten and Ferromolybdenum were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934. The specifications and methods appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 53 to 68, inclusive.

The withdrawal of the Standard Specifications for Tungsten Powder was approved.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 535.

REPORT OF COMMITTEE A-10

ON

IRON-CHROMIUM, IRON-CHROMIUM-NICKEL AND RELATED ALLOYS

Since the annual meeting of the Society last June, Committee A-10 has held one meeting in Washington, D. C., on March 9, 1934, during the Spring Group Meetings of A.S.T.M. Committees, and considerable progress has been made. Several changes in committee personnel have taken place, resulting in a membership of 60; of whom 25 are classed as producer, 25 as consumer, and 10 as general interest members.

Mr. I. B. McCorkle resigned the chairmanship of Subcommittee V on Mechanical Testing, which chairmanship was later accepted by Mr. C. A. Scharschu. Mr. N. L. Mochel found it necessary to relinquish the chairmanship of Subcommittee VIII on Specifications; this subcommittee was then disbanded and, as mentioned later in this report, its specification-making sections have been formed into individual subcommittees responsible for specifications for each type of product, under the leadership of temporary chairmen.

It was voted, during the Washington meeting, to hold a round-table discussion on the fabrication and performance of alloys falling within the scope of Committee A-10 as influenced by the various structural changes produced by thermal, mechanical and external chemical influences. A committee is to be formed to develop the program and make other necessary arrangements for this discussion which is to be held preferably during the 1935 Spring Group Meeting of A.S.T.M. Committees.

Subcommittee I on Classification of Data (T. H. Nelson, chairman).—Assembling of data on chemical, physical, mechanical and fabricating properties of alloys within the jurisdiction of the committee is under way. It is hoped to have these data for the June meeting. A scheme of numerical designation of alloys of different compositions has been established that will be strictly representative of the various materials. No reference to trade names or proprietary designations is being made.

Subcommittee III on Methods of Chemical Analysis (F. B. Foley, chairman).—Subcommittee III is continuing to collect and study methods of chemical analysis of the high chromium-nickel-iron alloys and some recommended procedures are anticipated shortly.

Subcommittee IV on Methods of Corrosion Testing (W. R. Huey, chairman).—Comments received on the 1933 report[1] of Subcommittee IV which presented the results of laboratory corrosion studies on four corrosion-resistant alloys using several methods of examination, have suggested additional work and, as a result of these suggestions, a program for further experiments by the subcommittee has been tentatively decided upon. The program suggested comprises work to improve the test methods previously studied by the subcommittee which included the salt spray test, the boiling nitric acid test and the copper sulfate stain test. Consideration is being given to an electrode potential test, half-tide sea-water immersion tests of refinished salt spray specimens and to further study of the copper sulfate test with respect to effect of surface finish on reproducibility of results. Ability to detect adverse heat treatment of corrosion-resisting steels by this test and the effect of variation of solution concentration upon the results are also to be studied. The salt spray and the boiling nitric acid test are to be further examined in an attempt to improve reproducibility of the former and decrease the time required for the latter.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 178 (1933).

The subcommittee has agreed to cooperate with Subcommittee VIII on Field Tests of Metallic Coatings of Committee A-5 on Corrosion of Iron and Steel in exposure tests of stainless wire and two cooperators have been named to assist Subcommittee VIII in selection and inspection of the wires.

Subcommittee V on Mechanical Tests (C. A. Scharschu, chairman).—The principal concern of this subcommittee is the elastic properties of alloys falling within the scope of Committee A-10. A program now being formulated will probably be available in June.

Subcommittee VI on Metallography (C. E. MacQuigg, chairman).—Subcommittee VI has had a report prepared for it by Mr. J. R. Vilella on "The Polishing and Etching of Iron-Chromium and Iron-Chromium Nickel Alloys," which covers in detail the suggested practice for polishing and etching the alloys for metallographic examination. This report is appended hereto. Additional problems to be undertaken by this subcommittee will be considered at the June meeting.

Subcommittee VII on Welding (F. B. Olcott, chairman).—This subcommittee has prepared what may be described as a recommended practice for the examination and inspection of welds in 18 per cent chromium, 8 per cent nickel alloy. Its submission as a tentative specification for welded articles made from this alloy was anticipated at the June meeting but such submission was deferred pending the study of new tests for corrosion resistance of welds, recently developed. These are now being examined critically.

Subcommittee VIII on Specifications.—This subcommittee has been discontinued in its original form and in its place there have been created four new subcommittees. Some changes have occurred in personnel, leaving specification sections in groups under temporary chairmen as indicated below:

Subcommittee VIII on Specifications for Wrought Products (Exclusive of Flats and Tubing), F. B. Foley, temporary chairman;

Subcommittee IX on Specifications for Flat Products, C. C. Snyder, temporary chairman;

Subcommittee X on Specifications for Castings, W. J. Jeffries, temporary chairman;

Subcommittee XI on Specifications for Tubing, temporary chairman not yet appointed.

Subcommittee IX, which will deal with sheet, strip and plate, is considering finish designations for sheets and expects to adopt a set similar to that now in use by manufacturers of stainless steels. Some elaboration as to use of materials with different finishes will be incorporated in the specifications when completed. Analyses are to be divided into four basic groups consisting of:

1. 10 to 15 per cent chromium.
2. 15 to 30 per cent chromium.
3. 18 per cent chromium, 8 per cent nickel.
4. Other chromium-nickel austenitic alloys exclusive of the 18 per cent chromium, 8 per cent nickel alloy.

Subcommittee X is considering methods of approaching a broad specification covering all heat- and corrosion-resistant cast alloys in which can be inserted details on each composition type; 18 per cent chromium, 8 per cent nickel alloys will be given first attention.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 60 members; 32 members returned their ballots, of whom 30 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

JEROME STRAUSS,
Chairman.

H. D. NEWELL,
Secretary.

APPENDIX

THE POLISHING AND ETCHING OF IRON-CHROMIUM AND IRON-CHROMIUM-NICKEL ALLOYS

BY J. R. VILELLA[1]

In describing the preparation of metallographic specimens of iron-chromium and iron-chromium-nickel alloys, it is advisable, because of the vast number of radically different metals involved, to classify them into three groups, basing this classification on the ease with which they can be polished and etched.

Group I.—Alloys containing more than 0.50 per cent carbon.
Group II.—Alpha or ferritic alloys containing less than 0.50 per cent carbon.
Group III.—Low-carbon gamma or austenitic alloys.

The alloys of group I are among the easiest of all metals to prepare for microscopic examination. Their hardness facilitates polishing and they are readily acted upon by suitable etching reagents. Groups II and III, on the other hand, consist of soft metals possessing a high corrosion resistance. Their preparation presents two difficulties requiring special treatment: namely,

(*a*) The surface metal tends to flow during polishing, forming a layer of severely cold-worked metal that must be removed in order to reveal the structures clearly;

(*b*) Due to their high chemical resistance the structures can be developed only by prolonged etching in strong acids, thus allowing the reagent ample time to act upon the non-metallic inclusions. This results in the formation of numerous pits. Group III, being the most resistant, is particularly susceptible to this condition.

Considered from the standpoint of polishing and etching, the chromium content of these alloys is a negligible factor; that is, two alloys with equal carbon content, one containing 13 per cent and the other 26 per cent of chromium are equally difficult to polish and etch; the nickel content is more important because nickel promotes austenite retention. However, given an austenitic alloy, the fact that it may contain 6, 12, or 18 per cent of nickel is of slight significance.

GROUP I—HIGH-CARBON ALLOYS

Polishing.—These alloys are generally too hard for hack-sawing. Suitable specimens are best secured by means of "cutting off" wheels—or by breaking off sections. Flat surfaces convenient for polishing may be obtained by grinding with abrasive wheels. Once a flat surface is obtained, the method of polishing later described, or any other method successfully employed in the preparation of steel samples will yield satisfactory results.

Etching.—The structures of these alloys are readily revealed by etching in the following reagent:

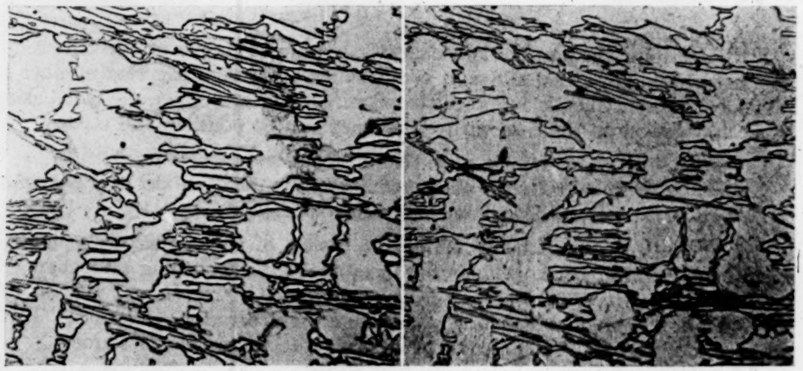
Reagent No. 1: 3 parts by volume of glycerol, 2 parts by volume of hydrochloric acid, and 1 part by volume of nitric acid.

---

[1] Metallographer, Union Carbide and Carbon Research Labs., Long Island City, N. Y.

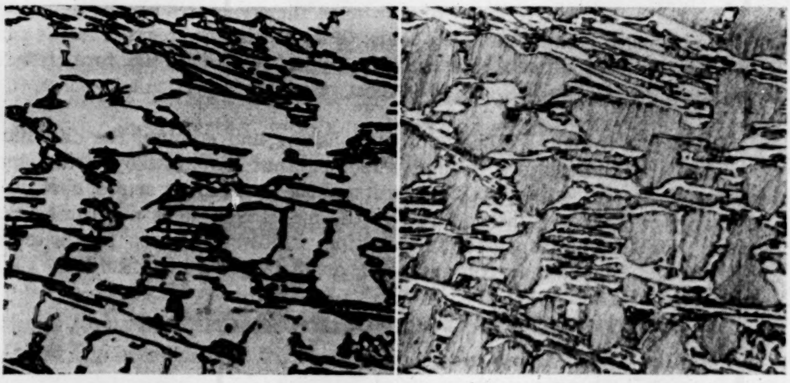
Prepare this reagent by adding the acids separately to the glycerol. Use only a freshly prepared solution and discard it when it acquires a strong chlorine color.

To etch proceed as follows: Warm the specimen in hot water and, without drying, subject it to the action of the solution. Etching time is usually from 3 to 10 sec. Keep the specimen in motion during etching. Wash with hot water followed by a few drops of 95 per cent alcohol, and dry by a gentle blast of air while the specimen is still warm.



(*a*) Etched with mixed acids in glycerol (reagent No. 1).

(*b*) Etched with 10 per cent boiling hydrochloric acid (reagent No. 2).



(*c*) Etched with alkaline potassium ferricyanide (reagent No. 3).

(*d*) Etched with acidified ferric chloride (reagent No. 4).

FIG. 1.—High-Carbon Iron-Chromium Alloy Containing About 28 per cent Chromium (× 250).

The following solutions are also suitable for etching this group of alloys.

Reagent No. 2.—10 per cent boiling hydrochloric acid. Etching time from 3 to 10 sec.

Reagent No. 3.—10 g. potassium ferricyanide, 10 g. potassium hydroxide, and 100 ml. water.

Darkens the carbides, thus increasing contrast. Etching time from 7 to 15 sec.

Reagent No. 4.—10 g. ferric chloride, 30 ml. hydrochloric acid, and 120 ml. water. Apply with a piece of cotton, rubbing gently. Solution may be diluted for slower action. Etching time from 3 to 10 sec.

Figure 1 illustrates the structure of a high-carbon, high-chromium alloy as developed by these reagents.[1]

GROUP II.—LOW AND MEDIUM CARBON ALPHA ALLOYS

This group comprises such metals as are commercially known by the terms rustless iron, stainless steel, chromium iron, ferrochromium and various other alloys ranging in carbon from traces to 0.50 per cent, and in chromium from 12 to 70 per cent. It includes also ferritic alloys containing additions of vanadium, tungsten, molybdenum, titanium, columbium or any other non-austenite forming element.

The majority of these alloys are heat-treatable. Their normal annealed structure consists of an iron-chromium solid solution in which are dispersed various amounts of free carbides, but structures corresponding to pearlite, sorbite, troostite and martensite can be imparted to some of these metals by heat treatment. All these structures can be satisfactorily brought out by the method to be described.

Polishing.—Regardless of how specular, free from scratches and optically flat a specimen may be, it is not perfectly polished unless, in addition, all its non-metallic inclusions have been preserved intact. If they are dislodged the metal will appear dirtier than it actually is, because a pit produced by improper polishing is generally larger and more conspicuous than the inclusion which formerly occupied its place. Obviously, if the inclusions are dislodged, their identification by microscopic methods is impossible. The method of polishing described below is recommended because it yields polished surfaces containing intact the non-metallic inclusions, and because, when properly carried out, it yields ideal surfaces for microscopic examination.

After securing a flat surface by grinding with abrasive wheels or by filing, proceed as follows:

1. Grind on Nos. 2, 1, 0, 00, and 000 emery papers successively, observing the usual precautions of crossing the scratches at right angles on passing from a coarser to finer paper and being particularly careful to press gently in order to avoid excessive distortion of the surface metal. A speed of 400 to 800 r.p.m. is satisfactory for an 8-in. disk.

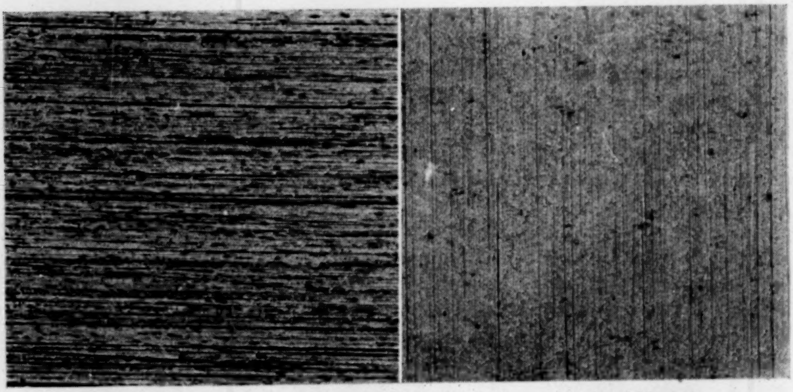
2. The scratches produced by 000 emery paper are too deep to be readily removed by the final polishing powders. An intermediate abrasive is necessary. 0000 paper is not recommended because its grit tends to be uneven. The use of wet powder abrasives, such as alundum or tripoli is satisfactory if only the grain structure of the alloy is to be examined, but if it is also desired to examine the non-metallic inclusions, then the use of such intermediate powders is not advisable, because they tend to remove the inclusions. Pitting can be avoided by the following procedure: Take the same sheet of 000 paper on which the sample was ground and glaze it by grinding on it a piece of graphite. Use this glazed paper in place of the intermediate powders, again being careful to press gently. The type of scratches produced by the last two papers are illus-

---

[1] The author refrains from commenting on the merits of the various reagents used in this comparison because he believes different results are possible in the hands of different workers, depending on their experience with the use of a particular reagent. The author has used for a long time and prefers reagent No. 1.

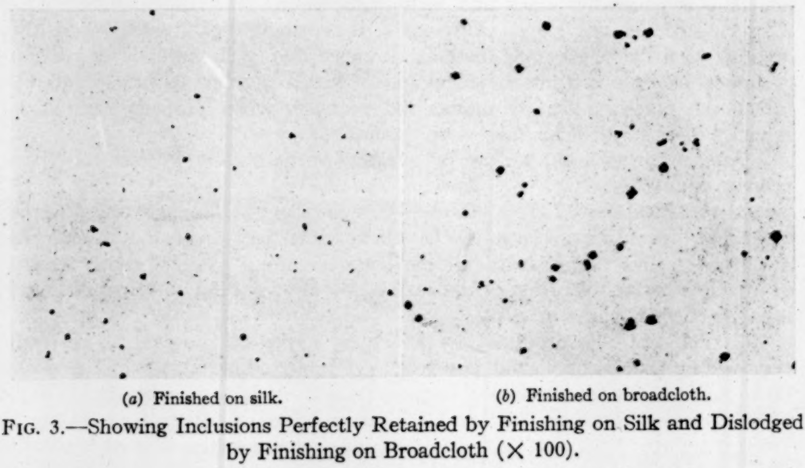
trated in Fig. 2. A sample ½ in. square thus ground can be finished on the final polishing cloth in 1 to 5 min.

3. Again, if only the grain structure is to be examined, then the sample may be finished on broadcloth, billiard cloth, "kitten's ear" or any other soft, high-pile fabric. But if the sample is to be photographed or the non-metallic inclusions examined, then it is advisable to employ a pileless fabric for the final polish. The dull side of heavy silk satin has been found to be the most satisfactory material for the purpose. Figure 3 illustrates a sample of rustless iron (unusually dirty) finished on silk and broadcloth respectively.



(a) Finished on No. 000 emery paper. (b) Finished on graphite-glazed No. 000 emery paper.

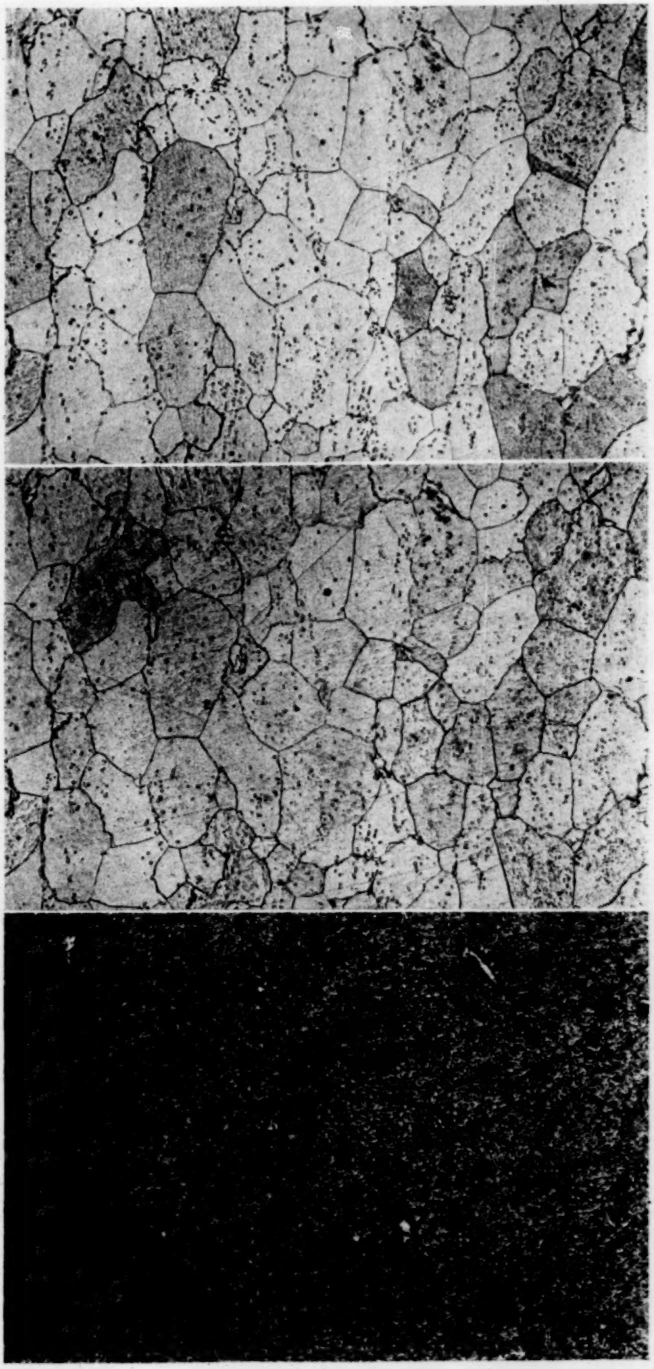
FIG. 2.—Showing Scratches Produced by No. 000 Emery Paper and Graphite-Glazed No. 000 Emery Paper (× 100).



(a) Finished on silk. (b) Finished on broadcloth.

FIG. 3.—Showing Inclusions Perfectly Retained by Finishing on Silk and Dislodged by Finishing on Broadcloth (× 100).

Concerning the various finishing powders, equally satisfactory results are possible by using levigated alumina, "heavy magnesium oxide" or rouge, but alumina has the advantage of being the cleanest and easiest to handle. A

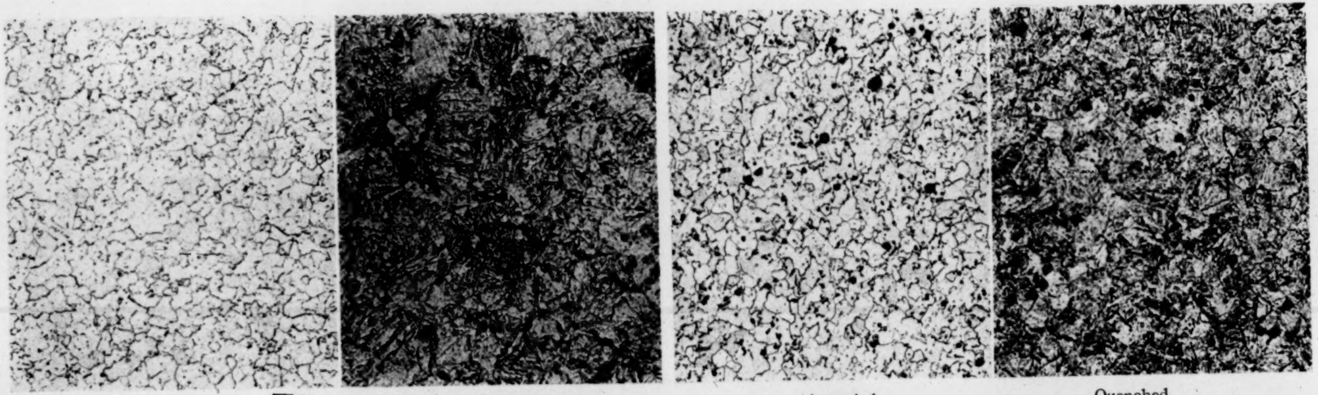


(a) Occurrence of disturbed metal.

(b) Same area repolished and re-etched.

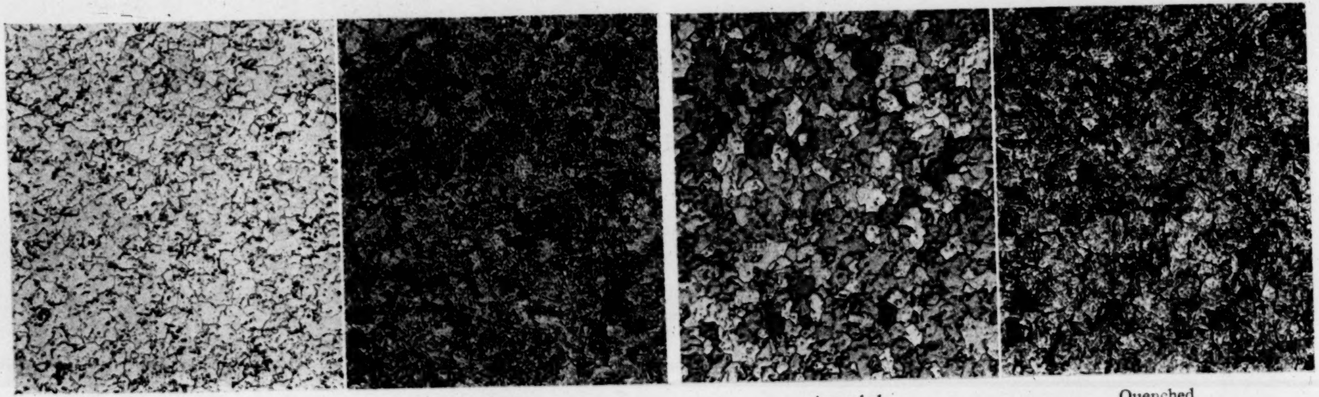
(c) Same area repolished and re-etched a second time.

FIG. 4.—Showing True Structure of an Alloy Containing About 28 per cent Chromium (× 100). Etched with Reagent No. 1.



Annealed Quenched
(*a*) Etched with mixed acids in glycerol (reagent No. 1).

Annealed Quenched
(*b*) Etched with acidified ferric chloride (reagent No. 4).



Annealed Quenched
(*c*) Etched with boiling 10 per cent hydrochloric acid (reagent No. 2).

Annealed Quenched
(*d*) Etched with acidified copper sulfate (reagent No. 5).

FIG. 5.—Results Obtained by Etching Two Samples of Rustless Iron Containing About 14 per cent Chromium (× 100).

commercial grade of alumina sold as being "specially prepared for buffing metallographic specimens and cutlery" can be used, but it must be relevigated by the polisher. A satisfactory preparation can be obtained by suspending 100 g. of alumina in 1000 ml. of water for 40 min.

Etching.—As was stated before, the structure of these alloys often lies under a layer of cold-worked metal formed during polishing. Deep etching is not a satisfactory method of removing this layer, because it roughens and obliterates the fine details of the structure. The best procedure is as follows: Etch the sample in a suitable reagent and examine with the microscope. If the surface metal is cold worked, repolish on the last cloth and re-etch. If cold-worked metal is still present, repeat the process. As a rule three repolishings suffice, but occasionally more may be necessary. The gradual removal of cold-worked metal by this process is illustrated in Fig. 4.

Reagents Nos. 1,[1] 2, and 4 may be used for etching. The following solutions have also been proposed:

Reagent No. 5.—4 g. copper sulfate, 20 ml. hydrochloric acid, and 20 ml. water.

Reagent No. 6.—Saturated solution of ferric chloride in hydrochloric acid to which a little nitric acid is added. Use full strength.

Reagent No. 7.—100 ml. hydrochloric acid, 7 g. mercurous nitrate, and 100 ml. water.

The results obtained by etching two samples of rustless iron (as annealed and as quenched) in some of these reagents, are illustrated in Fig. 5. In every case the samples were ground on all the papers and finished on silk. Cold-worked metal, when present, was removed by the process of alternate polishing and etching.

In the author's opinion, reagent No. 1 is the most satisfactory because it brings out the structure more clearly and causes the least amount of pitting.

GROUP III—LOW-CARBON AUSTENITIC ALLOYS

This group includes the majority of the iron-chromium-nickel alloys of which the well-known 18 per cent chromium, 8 per cent nickel is probably the most frequently met. It also includes "Nichrome" and certain alloys of the iron-chromium-manganese series. Alloys partly ferritic and partly austenitic are relatively easy to prepare and belong more properly under Group II.

Polishing.—The method previously described is entirely satisfactory for this group. However, there are certain differences that should be noted. For example, in the alpha alloys cold working during polishing often results in a layer of flowed metal that masks the structure completely, while in the austenitic alloys the most common manifestation of cold working is a series of parallel striations occurring within certain grains. Compare Fig. 4 (*a*) and (*b*) with Fig. 6. As in the alpha alloys, cold-worked metal can be eliminated by alternate polishing and etching, but unfortunately these striations are so persistent that in the course of their elimination the non-metallic inclusions are likely to be badly pitted, thus spoiling the appearance of the structure. Figure 7 represents a typical view of the same specimen shown in Fig. 6 after removing all traces of cold-worked metal.

Another difference is that in a ferritic alloy if scratches are not visible before etching they will not be present after etching, while in the austenitic alloys innumerable scratches, not visible after polishing, appear on etching. To

---

[1] To accelerate the action of reagent No. 1 increase the proportion of hydrochloric acid.

FIG. 5.—Results Obtained by Etching Two Samples of Rustless Iron Containing About 14 per cent Chromium (× 100).

(*d*) Etched with acidified copper sulfate (reagent No. 5).

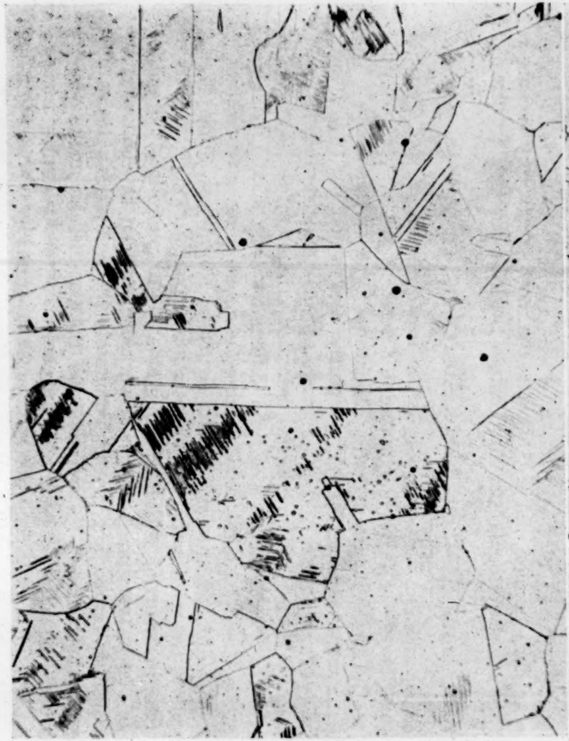


FIG. 6.—Showing Effect on Structure of Cold Work Produced by Polishing (× 250). Etched with Reagent No. 8.

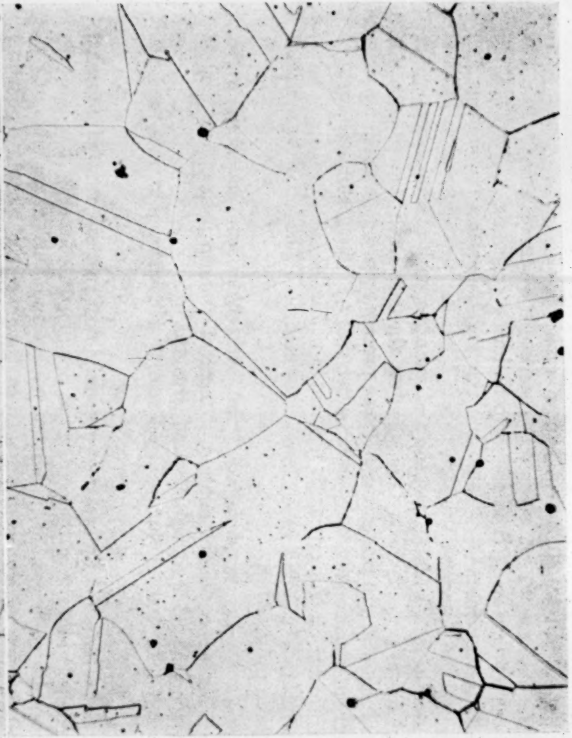


FIG. 7.—Same Specimen as Fig. 6 After Removing all Traces of Cold Work by the Method of Alternate Polishing and Etching (× 250). Etched with Reagent No. 8.

18 per cent chromium, 8 per cent nickel (KA$_2$S). Carbon 0.06 per cent, max. Commercially annealed.

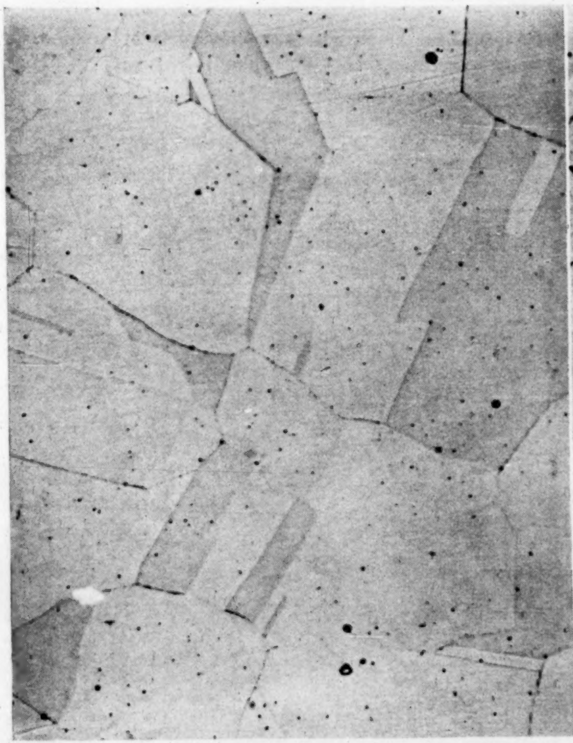


FIG. 8.—Lightly Etched, Photographed by Axial Illumination (× 500). Etched with Reagent No. 8.

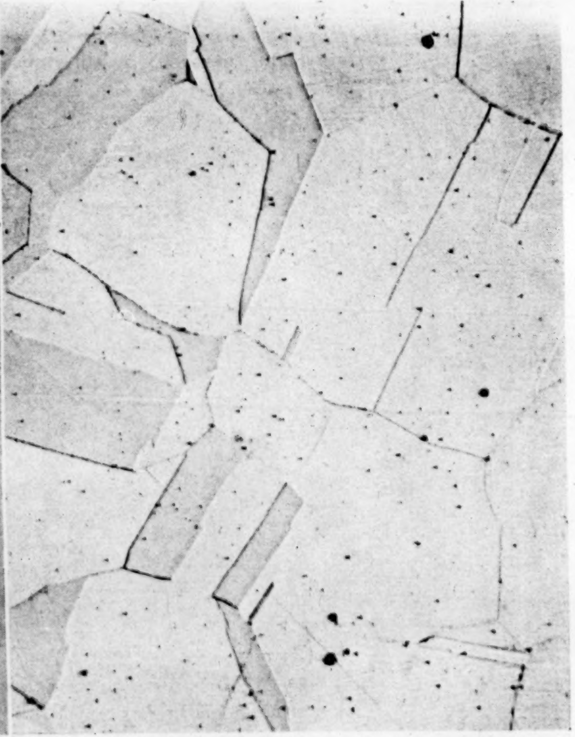


FIG. 9.—Same Field, Same Etching, Photographed by Conical Illumination (× 500). Etched with Reagent No. 8.

18 per cent chromium, 8 per cent nickel (KA_2S). Carbon 0.06 per cent, max. Commercially annealed.

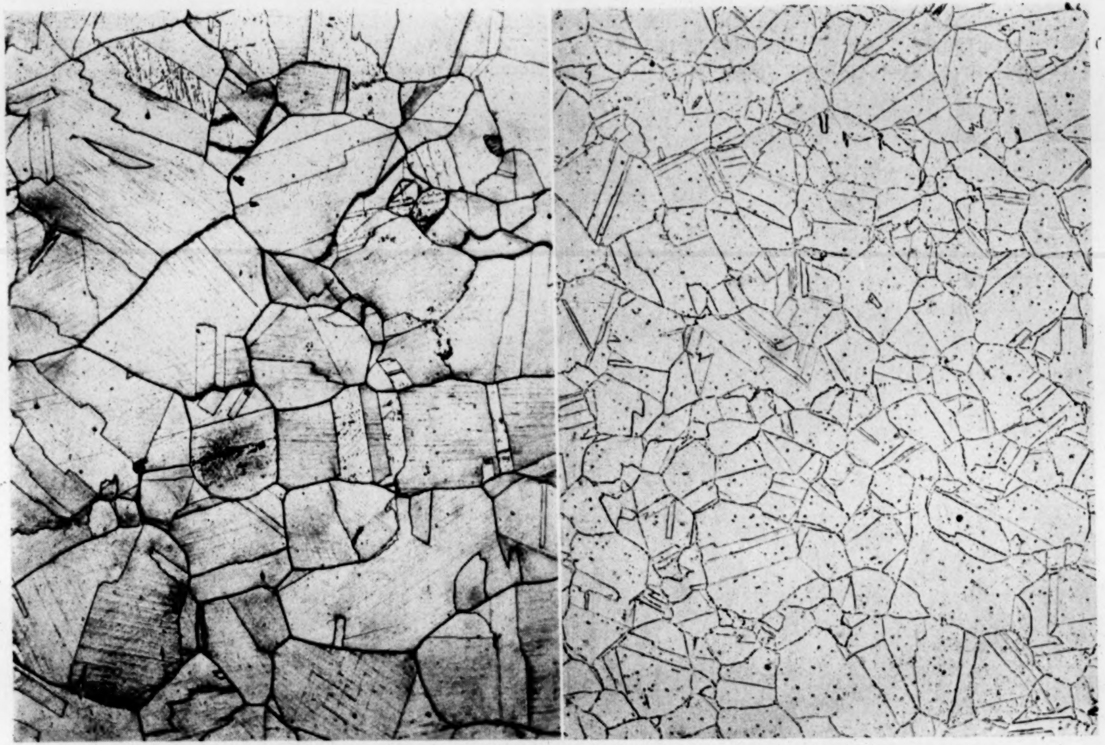


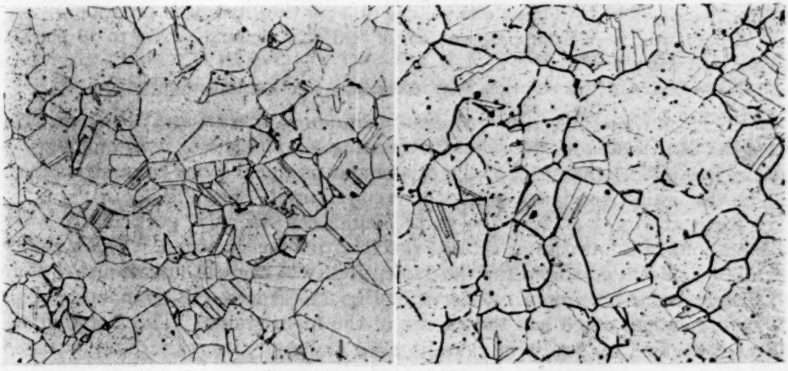
FIG. 10.—Illustrating Two Types of Carbide Precipitation at the Grain Boundaries (× 100).

When carbide separates out at the boundaries the structures are developed readily. Etched with Reagent No. 8.

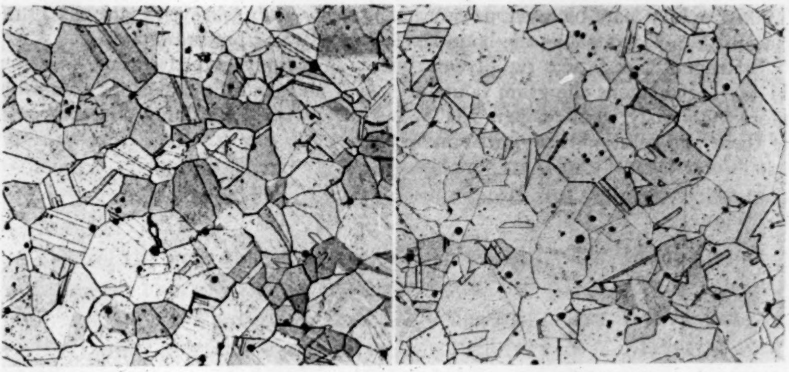
18 per cent chromium, 8 per cent nickel. Carbon between 0.10 and 0.15 per cent. Heat treatment unknown.

eradicate these it is advisable to finish on a very soft fabric, such as velvet, employing soap as a lubricant.

Etching.—The low carbon wrought alloys of this series are normally homogeneous, single phase metals. In order to reveal their structures it is necessary to create, by etching, a difference in level between adjoining grains. This requires prolonged etching in strong acids and frequently results in the formation of pits. A simple way of overcoming this difficulty consists in the employment of conical illumination, both for visual inspection and photomicrography. Conical illumination, however, is effective only at medium and high magnifications, and has the disadvantage of emphasizing scratches and other surface imperfections. The extent to which this method of illumination is helpful can be realized by inspection of Figs. 8 and 9 representing exactly the same area photographed by first axial and then conical illumination without any intervening etching.



(*a*) Etched with mixed acids in glycerol (reagent No. 8). (*b*) Etched with acidified ferric chloride (reagent No. 4).



(*c*) Etched with acidified copper sulfate (reagent No. 5). (*d*) Etched with chromic and hydrochloric acids (reagent No. 9).

FIG. 11.—Low-Carbon, 18 per cent Chromium, 8 per cent Nickel Alloy (× 100).
18 per cent chromium, 8 per cent nickel (KA$_2$S). Carbon, 0.06 per cent, max. Commercially annealed.

The proper etching of austenitic alloys is not always a difficult task. When the metal contains precipitated carbides at the grain boundaries the structure is readily brought out by a light etch. See Fig. 10.

Austenitic alloys can be etched with reagents Nos. 4, 5, 6 and the following:

Reagent No. 8.—2 parts by volume of glycerol, 2 parts by volume of hydrochloric acid, and 1 part by volume of nitric acid.

The action of this reagent can be accelerated by increasing the proportion of hydrochloric acid or by adding one volume of 3 per cent hydrogen peroxide.

Reagent No. 9.—25 parts by volume of hydrochloric acid, and 5 to 50 parts of 10 per cent chromic acid.

The activity of this solution is controlled by the amount of chromic acid.

Each of these reagents possesses distinctive merits and disadvantages. Reagent No. 8 acts slowly, thus minimizing the danger of over-etching. It causes less pitting than any of the others and produces a one-color structure in which the grain boundaries are not overemphasized. See Fig. 11 (*a*).

Reagent No. 4 attacks the grain boundaries strongly, particularly where segregations of impurities or carbide precipitation has occurred. This property should be helpful in estimating the susceptibility of iron-chromium-nickel alloys to intergranular corrosion. Observe in Fig. 11 (*b*) that the boundaries of the twins are etched much less than those of the main grains. The fact that this agent is applied by swabbing permits even etching. Its main disadvantage is that it attacks the non-metallic inclusions vigorously, producing pits.

The distinguishing characteristic of reagent No. 5 is its ability to color adjoining grains differently, depending on their orientation (see Fig. 11 (*c*)). This property can be used advantageously in grain size estimations. Like reagent No. 4, it attacks the boundaries strongly and produces pits.

Reagent No. 9 acts rapidly and yields an evenly etched surface (see Fig. 11 (*d*)). It attacks the grain boundaries and non-metallic inclusions somewhat more vigorously than reagent No. 8, but otherwise the etching characteristics of these two solutions are quite similar.

REPORT OF RESEARCH COMMITTEE
ON
FATIGUE OF METALS

During the past year the Research Committee on Fatigue of Metals has continued its cooperation with *Metals and Alloys* in publishing abstracts of articles relating to the Fatigue of Metals.

The research committee calls attention to the fact that the Edgar Marburg Lecture at the annual meeting of the Society last June by Dr. H. J. Gough[1] of the British National Physical Laboratory dealt especially with the crystallographic and atomic phenomena associated with the failure of metals under repeated stress. The committee feels that the delivery of this lecture, and the subsequent publication of it, both in the Society's *Proceedings* and as a separate reprint, was an important contribution to knowledge in the field of fatigue of metals.

The committee also notes with pleasure the award of the Charles B. Dudley medal for 1934 to the author of a paper bearing upon the fatigue of metals.[2]

The committee has entered into cooperative relations with a subcommittee of Committee E-4 on Metallography, which is studying X-ray methods of testing. Mr. R. F. Mehl is chairman of that subcommittee, and he, together with two members of our committee who are also located in the Pittsburgh region, are laying out and conducting preliminary experiments to study relations between metallographic and X-ray structures on the one hand and fatigue specimens on the other.

During the year there has appeared a paper by Mr. H. J. French,[3] describing a method of determining data for plotting a diagram, which he calls a "probable damage" diagram, and which can be produced on the same sheet with the ordinary *S-N* diagram, and which shows the probable line which locates combinations of stress and number of cycles below which no apparent damage is done to a given metal. "Damage" is here measured by the reduction of endurance limit of metal subjected to a given combination of stress and number of cycles below the endurance limit of the virgin metal.

---

[1] H. J. Gough, "Crystalline Structure in Relation to Failure of Metals—Especially by Fatigue," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 3 (1933).

[2] R. L. Templin, "The Fatigue Properties of Light Metals and Alloys," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 364 (1933).

[3] *Transactions*, Am. Soc. Steel Treating, Vol. XXI, No. 10, p. 899, October, 1933.

Several members of the committee are carrying on tests to determine such a "damage line" for various metals. The committee would be glad to communicate with any laboratory worker who feels that he could aid in this study.

The question of preparing a recommended practice for fatigue testing of metals—or at least for the more common fatigue tests—has come before the committee. It is not at all certain that the fatigue test has any great future as a test for acceptance or rejection of a metal. It is therefore uncertain whether standardization of methods would be of any great advantage at the present time. Premature standardization hinders rather than helps research work. On the other hand, standardization at any stage does make possible comparison of the work of different laboratories. The committee has asked one of its members to draw up a preliminary statement of recommended practice for rotating-beam fatigue tests, and plans to consider this question of recommended test methods with such a proposed outline of recommended practice before it as an example.

The committee held a meeting during the group meetings in Washington in March.

The election of a chairman for the ensuing term of two years resulted in the re-election of the present incumbent.

This report has been submitted to letter ballot of the committee which consists of 17 members; 12 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. F. MOORE,
Chairman.

REPORT OF JOINT RESEARCH COMMITTEE
ON
EFFECT OF TEMPERATURE ON THE PROPERTIES OF METALS

PROGRESS REPORT TO THE SPONSOR SOCIETIES

In accordance with the usual custom, there follows a summary of the activities of the Joint Research Committee for the year ending June, 1934.

Committee Meetings:

Three meetings were held during the year, at Chicago, Ill., in June, 1933, at New York in December, 1933, and at Washington, D. C., in March, 1934. Meetings of committees and subcommittees also were held, as required throughout the year, and contributed to the large amount of time devoted by the membership to the varied activities of the Joint Committee.

Membership:

Two additions were made to the membership. These comprise appointments of F. E. Bash, Driver-Harris Co., representing Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys of the American Society for Testing Materials, and in addition the heat-resistant alloy manufacturers; also of E. L. Robinson, General Electric Co., a representative of the turbine builders.

The Joint Committee, apart from its committees and subcommittees, is now comprised of 16 members located from the Eastern seaboard to Texas. With such a broad geographical distribution of its membership, full attendance of the committee can usually be secured only at regularly scheduled meetings. Circularization of this group has become increasingly difficult with gradual increase in the membership and, accordingly, the chairman was authorized to form a small executive group, with full power to act for the Joint Committee. This group, to be appointed in the near future, will handle those matters which require action between regularly scheduled meetings or those activities which obviously should not require the attention of the committee as a whole.

High Temperature Test Methods (Special Committee, N. L. Mochel, chairman):

The Tentative Methods of Test for Short-Time High-Temperature Tension Tests of Metallic Materials (E 21 – 33 T), and for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials (E 22 – 33 T), which were submitted to and issued as tentative standards by the American Society for Testing Materials in 1933, were discussed with representatives of industry and research laboratories and reviewed most carefully throughout the year by a special committee of five members, under the chairmanship of N. L. Mochel.

Certain changes[1] in the present tentative methods seem to be desirable, either to clarify the methods or to foster their broader application. The details of the proposed changes, which are given in the Appendix, were submitted to letter ballot and approved by the Joint Committee, which consists of 16 members, for submission to the sponsor societies. The results of the letter ballot are given in the following table:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF TENTATIVE STANDARDS			
Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials (E 21 – 33 T)	15	0	0
Method of Test for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials (E 22 – 33 T)	15	0	0

The forms for recording data under these two high-temperature test methods are now available and may be secured from the headquarters office of the American Society for Testing Materials.

Committee III on Projects (C. E. MacQuigg, chairman):

Sponsored Researches.—Sponsored researches relating to cast and wrought 18 per cent chromium, 8 per cent nickel steels, with different carbon contents, were continued at the Battelle Memorial Institute (H. W. Gillett), Columbus, Ohio, and at the University of Illinois (H. F. Moore), Urbana, Ill., under the guidance of Committee III on Projects.

The work planned last year was completed and a report, prepared by H. C. Cross, was presented at the December meeting of the American Society of Mechanical Engineers in New York, under the title, "High Temperature Tensile, Creep and Fatigue of Cast and

---

[1] The proposed revisions of the two tentative high-temperature test methods were submitted to the American Society for Testing Materials through its Committee E-10 on Standards on August 22, 1934, see Editorial Note, p. 212.—ED.

Wrought High- and Low-Carbon 18 Chromium, 8 Nickel Steel from Split Heats."[1] The report contains the results of repeated stress (fatigue) tests and creep tests within the temperature range 1000 to 1200 F.; impact tests at room temperatures, both before and after the several steels had been subjected to sustained stresses at elevated temperatures; metallographic studies of carbide precipitation; magnetic analysis and some corrosion test data.

Stresses required to produce failure by fatigue were much higher than those producing creep of 1 per cent in 10,000 hr. at corresponding temperatures throughout the temperature range investigated; these differences are similar in nature to those previously found in Joint Committee researches on carbon steels.

In both fatigue and creep tests, the high-carbon (0.12 per cent, approximate) wrought steels showed higher load-carrying ability than the low-carbon (0.07 per cent, approximate) steels. Carbon, therefore, may be said to have had a strengthening effect on the creep and fatigue resistance of these austenitic chromium-nickel steels, in line with previously published information.

The generalization sometimes made that coarse-grained cast steels have creep resistance superior to that of corresponding fine-grained wrought steels was not confirmed in the case of the 18 per cent chromium, 8 per cent nickel steels tested. The wrought steel, which at room temperature was stronger than the cast metal, was likewise more resistant to creep at the high temperatures, although the differences were not marked at 1200 F. The cast metal was also characterized quite generally by higher initial deformation than the corresponding wrought steel.

Contrary to the general opinion that "unstabilized" 18 per cent chromium, 8 per cent nickel steels, with carbon over about 0.02 per cent, show embrittlement as judged by impact tests at room temperature after a sojourn at 1100 to 1400 F., the low-carbon cast and wrought steels tested showed no reduction in impact values after being subjected to stresses at 1000 to 1200 F., for periods of from 750 to 1750 hr. Many of the samples of the higher carbon cast and wrought steels likewise showed no notable losses in impact resistance after being subjected to stresses at corresponding temperatures for similar periods of time.

Further studies of these phenomena, which are described in detail in the report in question, are now being given consideration.

Organization of subcommittees.—In the reorganization of the working committees of the Joint Committee about two years ago,

---

[1] *Transactions*, Am. Soc. Mechanical Engrs., July, 1934.

Committee III on Projects provided for fifteen subcommittees to handle various phases of its work. Three of these, Subcommittee B on Selection of Cooperating Laboratories and Arrangement, Subcommittee I on New Methods of Test, and Subcommittee L on Physical Constants, were never completely organized, the work being taken care of by other groups. These three subcommittee titles were, therefore, eliminated during the year. Subcommittee C on the Development of Reference Test Methods, and Subcommittee K on Thermal Expansion completed the tasks for which they were formed and were discharged with thanks, duly recorded in the minutes of the Joint Committee. Since the adoption of the two tentative high-temperature test methods, E 21 – 33 T and E 22 – 33 T, the work of Subcommittee C has been allocated to the Special Committee previously mentioned in this report. This leaves ten active subcommittees in Committee III (see organization chart in the 1932 Annual Report).[1]

Committee IV on Publications (H. W. Gillett, chairman):

The functions of Committee IV on Publications include the assembly and preparation of data for publication, review of committee reports, preparation of news items and the handling of details incident to the sponsorship of technical sessions or of papers by individuals.

Sponsorship by the Joint Committee of papers prepared by individuals requires approval of the Publication Committee to the extent that expert reviewers are satisfied that definite contributions are being made to the knowledge in the field of the committee's work. It does not indicate, necessarily, that the committee subscribes to the conclusions or vouches for the accuracy of the data, but it signifies that the Joint Committee believes the papers to be deserving of attention and discussion by the sponsor societies.

In addition to its report of sponsored researches on the stainless steels (paper by H. C. Cross, referred to previously), Committee IV (for the Joint Committee), in cooperation with the A.S.M.E. Committee on Plasticity, sponsored a technical session at the December Annual Meeting of the American Society of Mechanical Engineers, at which the following papers were presented:

> "Factors Affecting Choice of Working Stresses for High-Temperature Service," by P. G. McVetty.[2]
>
> "The Elastic Properties of Steel at High Temperatures," by Guy Versé.[3]

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 149 (1932).

[2] *Transactions*, Am. Soc. Mechanical Engrs., Applied Mechanics Section (A.P.M. 55 – 13), July-September, 1933.

[3] To be published in an early issue of the 1935 *Transactions* of the Am. Soc. Mechanical Engrs.

It has also arranged for the sponsorship, at the June, 1934, Meeting of the American Society for Testing Materials, of three papers by individual members of committees or subcommittees as follows:

> "The Interpretation of Creep Tests," by P. G. McVetty.[1]
>
> "Creep Properties of 5 per cent Chromium, 0.50 per cent Molybdenum Steel Still Tubes," by H. C. Cross and E. R. Johnson.[1]
>
> "Aging Embrittlement of 4 to 6 per cent Chromium Steel," by H. M. Wilten and E. S. Dixon.[1]

With Committee III on Projects, Committee IV, through editorials and notices in the technical press, has endeavored to enlist the cooperation of industrial and university testing laboratories in perfection and more general utilization of the two tentative high-temperature test methods, E 21 – 33 T and E 22 – 33 T.

Interested laboratories have been invited to secure samples from the Joint Committee's supply of carbon steels, carefully tested for uniformity, for inter-comparison of creep and tension test results secured under the requirements of the high-temperature test methods. The response so far indicates that many of those organizations interested in the high-temperature properties and testing of steels will avail themselves of this opportunity, leading toward effective standardization of high-temperature test methods.

Committee V on Oil Refinery Problems (A.P.I. and A.A.S.M. Cooperating) (H. J. French, acting chairman):

Committee V on Oil Refinery Problems, organized in March, 1933, held two meetings during the year, in addition to meetings of subcommittees, and decided that the most pressing problems relate to still tube materials.

Consideration was given to the details of a program for studying the performance of still tube steels in actual oil refinery service. This plan, requiring the cooperation of the oil refiners, the steel manufacturers, the tube makers, and the committee, naturally brought to light many points of view and necessitated considerable discussion of details. At the present time, the committee can report that it has an acceptable plan of procedure, but that adequate financing is yet to be secured. Progress during the coming year depends quite largely upon the procurement of the necessary funds.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part II, pp. 105, 80 and 59 (1934).

Funds:

On application, through the Headquarters Office of the American Society of Mechanical Engineers, the Joint Committee was granted additional funds of $3000 by Engineering Foundation. While this grant originally was requested in support of a specific project, it is of interest to make note of the comments of one member of the Reviewing Committee, Engineering Foundation, as follows:

> "The study of metals at high temperature is of general interest to more than the mechanical engineer. A good deal is being spent independently in different industrial laboratories and with considerable duplication. It seems as though this is a case where industry should contribute to a central, well-directed research and avoid a great deal of duplication."

These funds, available during the present calendar year, and with the balance on hand from previous contributions from various sources will give the Joint Committee a working capital in the neighborhood of $6000 for continuation of its sponsored researches.

Respectfully submitted on behalf of the Joint Committee,

H. J. FRENCH,
Chairman.

N. L. MOCHEL,
Secretary.

EDITORIAL NOTE

Recommendations to Committee E-10 on Standards.—Subsequent to the annual meeting the Joint Research Committee on Effect of Temperature on the Properties of Metals presented to the American Society for Testing Materials through Committee E-10 on Standards the following recommendations which were accepted by Committee E-10 on August 22, 1934:

Revisions of the Tentative Methods of Test for Short-Time High-Temperature Tension Tests of Metallic Materials, and for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials were accepted. The revisions are given in the Appendix to this report, and the specifications in their revised form appear on pages 1214 and 1223, respectively.

APPENDIX

PROPOSED REVISIONS IN TENTATIVE METHODS FOR HIGH-TEMPERATURE TENSION TESTS OF METALLIC MATERIALS

In this Appendix are given the proposed revisions of the two tentative standards referred to in the body of the report. Reference is given to the publications in which the tentative methods appear in their present form.

Tentative Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials (E 21 – 33 T):[1]

Section 2.—Add the following note at the end of this section:

NOTE.—In the testing of some materials it is customary and often necessary to subject the specimens to a stabilizing treatment. If such is done, it shall be reported fully in the recorded data.

Section 4.—Add the following as a new Paragraph (*b*), relettering the present Paragraph (*b*) as Paragraph (*c*):

(*b*) Precautions shall be taken to insure that the testing load is axially applied. Each specimen when set up for test shall be inspected for faulty alignment in the machine. Eccentricity of loading can often be detected by elastic extension measurements taken at room temperature before commencing the test. Apparatus provided with extensometers affording measurements on opposite sides will reveal unsatisfactory alignment when unequal strain is shown by the opposite readings. Elongation measuring devices which show extension on one side of the specimen only do not readily lend themselves to the detection of eccentric loading.

Section 5.—Change Paragraph (*a*) to read as follows by the addition of the italicized word and the omission of the word in brackets:

5. (*a*) A drawing showing the furnace and heating [coil] *element* in detail shall be submitted with the results of a series of tests.

Omit the present Paragraph (*b*) and reletter Paragraph (*c*).

At the end of Section 5 add the following Note which replaces the Paragraph (*b*) now being omitted and also includes the Note which appears after Paragraph (*c*):

NOTE.—It should be noted that the transverse dimensions of the furnace should be as small as possible, merely large enough to allow for the shackles and extensometer. Any suitable arrangement of the heating element that will result in the required uniformity of temperature is considered satisfactory. It may be noted that equalization of temperature over the length of the test specimen may be improved by a metallic lining inside the furnace tube, or by the use of multiple heating coils. Liquid baths may be used at lower temperatures provided that no reaction of the liquid upon the test metal occurs. Oil is suitable at lower temperatures. No definite recommendations are made as to the length of the furnace, provided the required uniformity of temperature is realized. Reference to the various publications of the Joint Research Committee is suggested for guidance.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 996 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 1030.

Section 10.—Change this section from its present form: namely,

10. The details of the extensometer used for strain measurements are not specified, but they shall be reported with the results of tests. The extensometer shall read directly to 0.0002 in. or less for a 2-in. specimen. The extensometer may be attached to the rods or the ends of the shackles projecting beyond the furnace, or optical methods of measurement may be employed.

to read as follows:

10. There shall be reported with the results of all tests, the construction details of the extensometer used, the method of attaching it, and any optical methods for taking strain measurements. The extensometer shall read directly to 0.0002 in. or less for a 2-in. specimen. Whenever feasible, the extensometer should be attached to the gage length of the test specimen, but it is permissible to attach the extensometer to the ends of the shackles projecting beyond the furnace. It is also permissible to employ suitable optical methods of measurement.

NOTE.—Extensometers attached to the rods or shackles beyond the furnace apparently give satisfactory results as to yield strength; but in the determination of elastic modulus, the extension should be taken over a definite portion of the gage length.

Tentative Method of Test for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials (E 22 – 33 T):[1]

Section 1.—Change Paragraph (*b*) to read as follows by the addition of the italicized words and the omission of those in brackets:

(*b*) Long-time tension tests [shall be] *are* made at those elevated temperatures where creep effects assume technical or engineering importance. The [range] *ranges* of temperature [that should be] *usually* investigated [for some of the important classes of metals] are as follows:

Change the last item in the table following Paragraph (*b*) to read as follows by the addition of the italicized figures and the omission of those in brackets:

Copper and aluminum alloys........................[300] *200* to 800 F.

Change Paragraph (*c*) to read as follows by the addition of the italicized words and the omission of those in brackets:

(*c*) Testing temperatures shall [in all cases] be established [only] at points that are multiples of 50 on the Fahrenheit scale, *or equivalents on the Centigrade scale. It is recognized that for special purposes, tests at other temperatures may be desirable to establish the creep characteristics.*

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 1004 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 1038.

Omit Paragraph (*d*) which reads as follows:

(*d*) Tests undertaken for the purpose of locating limiting service temperatures or critical temperatures, shall be made at each 50 F. interval on the narrowest range in which the limiting or critical temperature is shown to exist by previous investigations.

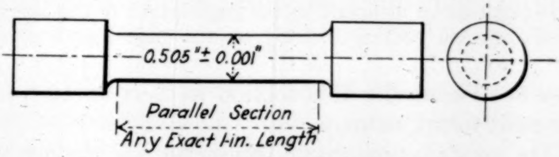
Section 2.—Add the following note at the end of this section:

NOTE.—In the testing of some materials it is customary and often necessary to subject the specimens to a stabilizing treatment. If such is done, it shall be reported fully in the recorded data.

Figure 1.—Reletter the present Fig. 1 as Fig. 1 (*a*) and insert the accompanying figure as Fig. 1 (*b*).

Section 3.—Change this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

3. (*a*) [Test specimens, wherever possible, shall be of the usual type for 2-in. gage length, see Fig. 1, as described in Section 15 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.] *Test specimens may be of either of the types shown in Fig. 1* (*a*) *or 1* (*b*). The diameter of the test specimen shall preferably be 0.505 in ±0.001 in. In cases where small diameter is imperative, specimens having a diameter of [either] 0.357 in. or 0.252 in. may be used, but the gage length shall be not less than 2 in. The diameter of the reduced section of the specimen between base of fillets shall not vary by more than ±0.0005 in. The surface shall be machined smooth and free from tool marks or scratches, [It shall be] *and* finished [by polishing] with No. 00 emery cloth.



(*b*) Specimen with blank ends.

FIG. 1.—Test Specimen for High-Temperature Tension Tests.

(*b*) *In the case of Fig. 1* (*a*), the ends of the test specimen shall be threaded, at least ¾ in. in diameter for the 0.505-in. specimen, ½ in. in diameter for the 0.357-in. specimen, and ⅜ in. in diameter for the 0.252-in. specimen, and shall be machined true and axial.

(*c*) A sketch showing the [type of] specimen used shall accompany the report of test results.

Section 5.—Change Paragraph (*a*) to read as follows by the addition of the italicized word and the omission of the word in brackets:

5. (*a*) A drawing showing the furnace and heating [coil] *element* in detail shall be submitted with the results of a series of tests.

Omit the present Paragraph (*b*) and reletter Paragraph (*c*).

At the end of Section 5 add the following Note which replaces the Paragraph (*b*) now being omitted and also includes the Note which appears after Paragraph (*c*):

NOTE.—It should be noted that the transverse dimensions of the furnace should be as small as possible, merely large enough to allow for the shackles and extensometer. Any suitable arrangement of the heating element that will result in the required uniformity of temperature is considered satisfactory. It may be noted that equalization of temperature over the length of the test specimen may be improved by a metallic lining inside the furnace tube, or by the use of multiple heating coils. Liquid baths may be used at lower temperatures provided that no reaction of the liquid upon the test metal occurs. Oil is suitable at lower temperatures. No definite recommendations are made as to the length of the furnace, provided the required uniformity of temperature is realized. Reference to the various publications of the Joint Research Committee is suggested for guidance.

New Section.—Add the following section on strain measurement as Section 9, renumbering the present Section 9 as Section 10:

9. There shall be reported with the results of all tests, the construction details of the strain measuring apparatus used. Scale divisions on the extensometer shall not be larger than 0.0001 in. per in. of gage length. It is preferable that the extensometer be attached to the gage length of the specimen, or that suitable optical means bearing directly on the gage length of the specimen be used.

Section 9.—Renumber this section as Section 10 and change it from its present form: namely,

9. (*a*) The constant-temperature, constant-stress method shall be employed in creep tests. Stresses to produce creep at the rate of 1.0 per cent per 10,000 hr. and 0.1 per cent per 10,000 hr. in the secondary flow period shall be determined. For some applications it may be necessary or desirable to determine the stress to produce creep at the rate of 0.01 per cent per 10,000 hr. in the secondary flow period. (See Section 10.)

(*b*) A preliminary exploration shall be made. A number of specimens shall be subjected, at constant temperature, to different stresses in pounds per square inch selected from those in the following list: 250, 500, 750, 1000, 2000, 3000, 5000, 7500, 10,000, 15,000, 20,000, 25,000, 30,000, 40,000, 50,000, 60,000, 70,000 lb. per sq. in., etc. No specimen shall be used for more than one test at the stress and temperature selected. This exploration will provide an estimation of the creep-stress relations, at the selected temperatures.

(*c*) From this estimation, additional tests shall be made on individual specimens at such loads in round hundreds or thousands of pounds per square inch, suitable to the material and temperature, as to achieve the desired object.

to read as follows:

10. The constant-temperature, constant-stress method shall be employed. Tests shall be made on individual specimens at such loads in round hundreds or thousands of pounds per square inch, suitable to the material and temperatures, and tests shall be made in such number and for such time periods as to achieve the desired object.

Section 10.—Omit this section from the body of the test method and include it as an appendix, renumbering the subsequent sections accordingly.

REPORT OF COMMITTEE B-2
ON
NON-FERROUS METALS AND ALLOYS

Committee B-2 held one meeting during the year, in Chicago, Ill., on June 29, 1933. Another meeting of the committee is to be held during the annual meeting of the Society in Atlantic City, N. J., immediately prior to the presentation of this report.

Subsequent to the 1933 annual meeting, as mentioned in the annual report last year,[1] the committee presented to the Society through Committee E-10 on Standards revisions of the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 – 28 T) and of the Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 – 27); the latter revision is in the form of a new tentative method entitled, "Tentative Method of Determination of Phosphorus in Copper-Base Alloys in Ingot Form for Sand Castings (B 45 – 33 T)" which is to be added, when adopted, to the present Standard Methods B 45. These revisions were accepted for publication as tentative[2] by Committee E-10 on September 2, 1933, and appear in the 1933 *Proceedings*.[3]

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Pure Metals in Ingot Form (W. H. Bassett, chairman).—This subcommittee at its meeting in June, 1933, formulated certain changes in the three grades of lead covered by the Standard Specifications for Pig Lead (B 29 – 23).[4] Amendments of these changes were subsequently considered by the subcommittee at a meeting in March, 1934, and the proposed revisions were approved for submission to letter ballot of the subcommittee. These proposed changes in the Standard Specifications B 29 will be presented to Committee B-2 at a meeting to be held at the annual meeting of the Society and, if approved by Committee B-2, the proposed revisions will be presented to the Society through Committee E-10 on Standards during the summer for publication as a tentative revision of the standard specifications.[1] The revisions which the subcommittee intends to present to Committee B-2 include a revised scope clause and changes in chemical composition of the three grades of pig lead covered by the specifications. The new scope clause and the proposed revised compositions are as follows:

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 229, 230 (1933).

[2] In submitting these revisions to Committee E-10 on Standards, the committee reported the following results of the letter ballot vote of a total of 58 ballots returned from a committee membership of 99: Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 – 28 T), 32 affirmative and none negative; Tentative Method of Determination of Phosphorus in Copper-Base Alloys in Ingot Form for Sand Castings (B 45 – 33 T), 33 affirmative and none negative.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 620, 638 (1933); also 1933 Book of A.S.T.M. Tentative Standards, pp. 213, 247.

[4] 1933 Book of A.S.T.M. Standards, Part I, p. 786.

Scope.—These specifications are intended to cover lead in pig form, made from ore or other materials, by processes of reduction and refining, and not reclaimed lead. Lead complying with these specifications is intended to be refined lead, produced by lead producers who use well recognized and accepted processes for smelting and fully refining their products. Reclaimed lead which is prohibited by these specifications is a commercial product obtained by the recovery of metallic lead and its alloys, by the simple reclaiming process of melting, drossing and casting.

Corroding Lead (*Grade I*) shall conform to the following requirements as to chemical composition:

Silver, max., per cent	0.0015
Copper, max., per cent	0.0015
Copper and silver together, max., per cent	0.0025
Arsenic, max., per cent	0.0015
Antimony and tin together, max., per cent	0.0095
Zinc, max., per cent	0.0015
Iron, max., per cent	0.002
Bismuth, max., per cent	0.05
Lead (by difference), min., per cent	99.94

NOTE.—The maximum limits for bismuth, copper and silver have been given, but it is not expected that any delivery will contain the maximum of all three.

Chemical Lead (*Grade II*) is a designation that has been used for many years in the trade to describe the undesilvered lead produced from Southeastern Missouri ores. Chemical lead shall conform to the following requirements as to chemical composition:

Silver, per cent	0.020, max. 0.002, min.
Copper, per cent	0.080, max. 0.040, min.
Antimony, arsenic and tin together, max., per cent	0.002
Zinc, max., per cent	0.001
Iron, max., per cent	0.0015
Bismuth, max., per cent	0.005
Lead (by difference), min., per cent	99.90

Common Lead (*Grade III*) shall conform to the following requirements as to chemical composition:

---

[1] The proposed revision of the Standard Specifications for Pig Lead was accepted by Committee E-10 on Standards subsequent to the annual meeting, see Editorial Note, p. 220.—ED.

Silver, max., per cent	0.002
Copper, max., per cent	0.0025
Arsenic, antimony and tin together, max., per cent	0.015
Bismuth, max., per cent	0.15
Iron, max., per cent	0.002
Zinc, max., per cent	0.002
Lead (by difference), min., per cent	99.85

Note.—Common Lead (Grade III*a*) conforms to the above analysis except that bismuth shall not be over 0.25 per cent and the total purity shall not be less than 99.73 per cent lead.

Subcommittee IV on White Metals—Tin, Lead and Zinc (G. H. Clamer, chairman).—This subcommittee has under consideration the revision of the Standard Specifications for White Metal Bearing Alloys (known commercially as "Babbitt Metal") (B 23 - 26) as far as the chemical compositions of Alloys Nos. 1, 2 and 3 are concerned. Manufacturers and principal users of type metals are also being canvassed to determine the desirability of formulating specifications for metals used in the printing trades.

Subcommittee VII on Methods of Chemical Analysis (H. V. Churchill, chairman).—Subcommittee VII has been comparatively inactive. No comments have been received on the standard methods except one on the determination of silicon in aluminum. This matter is under investigation as well as the preliminary investigation of analytical standards for commercial magnesium and commercial tin.

Subcommittee XII on Metallic Fluxes and Deoxidizers (C. E. Margerum, chairman).—This subcommittee has been inactive for several years, during which time several new proprietary articles have been placed on the market, and a considerable amount of literature has appeared. A canvass of the situation is being made to discover any items worthy of detailed investigation.

Subcommittee XIII on Strip Zinc (E. H. Bunce, chairman).—Subcommittee XIII has under consideration the submission of the Standard Specifications for Rolled Zinc (B 69 - 29) to the American Standards Association for approval as American Standard. Some objections have been received from producers of the material, and the subcommittee is now cooperating with the American Zinc Institute with a view to formulating acceptable modifications in the specifications.

Subcommittee XVI on Coated Metals (W. G. Schneider, chairman).—This subcommittee, organized about a year ago, has undertaken a study of the commercial requirements of lead-coated sheet copper, principally used for architectural purposes. Proposed specifications have been outlined and are receiving consideration by the subcommittee members.

At the meeting of the committee held during the annual meeting, the resignation of Professor William Campbell as chairman of the committee was presented. In appreciation of the services which he rendered to Committee B-2 as its chairman for a period extending over 25 years, the committee adopted the following resolution in electing Professor Campbell to the office of Honorary Chairman:

WHEREAS, Professor William Campbell has served Committee B-2 faithfully and well as its chairman ever since its organization; and

WHEREAS, we note with regret that the state of his health has prevented full participation in the activities of the committee for some time, and he has expressed the opinion that he should retire as active chairman;

THEREFORE, BE IT RESOLVED, that a proper minute be placed in the Society's records, gratefully acknowledging the debt which we owe him for his leadership, from which has come so many of the achievements of Committee B-2 and its various offshoots, and

FURTHER BE IT RESOLVED, that in order to avail of Professor Campbell's counsel in the future, the office of Honorary Chairman be established, and that he be asked to accept this post of honor.

The election of officers for the ensuing term of two years resulted in the re-election of the present vice-chairmen and secretary.

This report has been submitted to letter ballot of the committee which consists of 95 members; 72 members returned their ballots, of whom 63 have voted affirmatively and 3 negatively.

Respectfully submitted on behalf of the committee,

WILLIAM CAMPBELL,
Chairman.

E. E. THUM,
Secretary.

EDITORIAL NOTE

Recommendation to Committee E-10 on Standards.—Subsequent to the annual meeting Committee B-2 on Non-Ferrous Metals and Alloys presented to the Society through Committee E-10 on Standards proposed Tentative Specifications for Pig Lead to replace the existing standard specifications. The proposed specifications were accepted for publication as tentative by Committee E-10 on August 22, 1934, and appear on page 662. Since the new tentative specifications were intended to supersede the Standard Specifications for Pig Lead, the proposed withdrawal of the standard was also approved by Committee E-10.

REPORT OF COMMITTEE B-3
ON
CORROSION OF NON-FERROUS METALS AND ALLOYS

Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys has been active during the past year through its Subcommittees VII and VIII, primarily in carrying forward the programs of corrosion tests in the field under the sponsorship of those two subcommittees.

The 1932 report of the committee gave complete information with regard to the materials being studied by these subcommittees in their tests and described in detail the program of tests planned by each.[1]

Subcommittee VI on Atmospheric Corrosion (W. H. Finkeldey, chairman).—Subcommittee VI presented its report of results obtained after one year of atmospheric exposure on some 24 non-ferrous metals and alloys in the 1933 report of this committee. This subcommittee's program of atmospheric exposure of these various materials is continuing and after the next period of exposure a report similar to that of last year will be prepared.

Subcommittee VII on Corrosion in Liquids (R. J. McKay, chairman).—Considerable progress has been made in the test program of Subcommittee VII and appended hereto is a detailed report of this subcommittee.

Subcommittee VIII on Galvanic and Electrolytic Corrosion (C. L. Hippensteel, chairman).—The testing program of Subcommittee VIII has also progressed and this subcommittee has prepared a report, appended hereto, which contains detailed data obtained from studies after the first period of exposure under its program.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 51 members; 30 members returned their ballots, of whom 26 have voted affirmatively and 4 negatively.

Respectfully submitted on behalf of the committee,

T. S. Fuller,
Chairman.

Sam Tour,
Secretary.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 201 (1932).

REPORT OF SUBCOMMITTEE VII ON CORROSION IN LIQUIDS

As stated in an earlier report,[1] the test program of Subcommittee VII is being carried out for the purpose of providing information and data useful in studying the standardized laboratory corrosion tests to be developed by Committee B-3. The object has not been to compare the performance of the various metals that are offered for corrosion-resisting purposes, nor has the object been to include every metal that is or may be useful against the corrosives that were selected. Consequently, no definite conclusions should be drawn from the data presented as to which metal is most resistant against the corrosives.

Subcommittee VII has made progress on its corrosion testing program, which was outlined in the 1932 report.[2] The tests against sulfuric acid are well along toward completion. The subcommittee is in a position to report weight loss data on 315 specimens exposed to sulfuric acid, and to report the data from tension tests on 162 of the corroded specimens. The tests against sodium hydroxide were started in February, 1934, and the tests against sodium chloride in May, 1934. The tests against hydrochloric acid have not progressed and it will be necessary to make new arrangements for the work, which is being done.

Information regarding the source, composition, structure, tensile strength, elongation, and designation of the metals being tested by the subcommittee may be found in the 1932 report.[3] The form and dimensions of the metal specimens[4] are also shown in this earlier report and as stated in that report, the specimens of the rolled metals K, Q, and R were not machined properly and they do not conform exactly with the standard tension test specimen for thin sheet metals.

Sodium Chloride:

Mr. W. R. Webster, Bridgeport Brass Co., is chairman of Section 1, which is testing the metals A, B, C, D, E, F, H, J, K, L, M, N, P, Q, R, S, T, V, W, and Y against sea water and against saturated brine.

After cleaning and weighing, the specimens were mounted in the racks as illustrated in Fig. 1. The method of attaching the specimens to the rack is shown in Fig. 2.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 195 (1926).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 243 (1932).

[3] *Ibid.*, p. 215.

[4] *Ibid.*, p. 244.

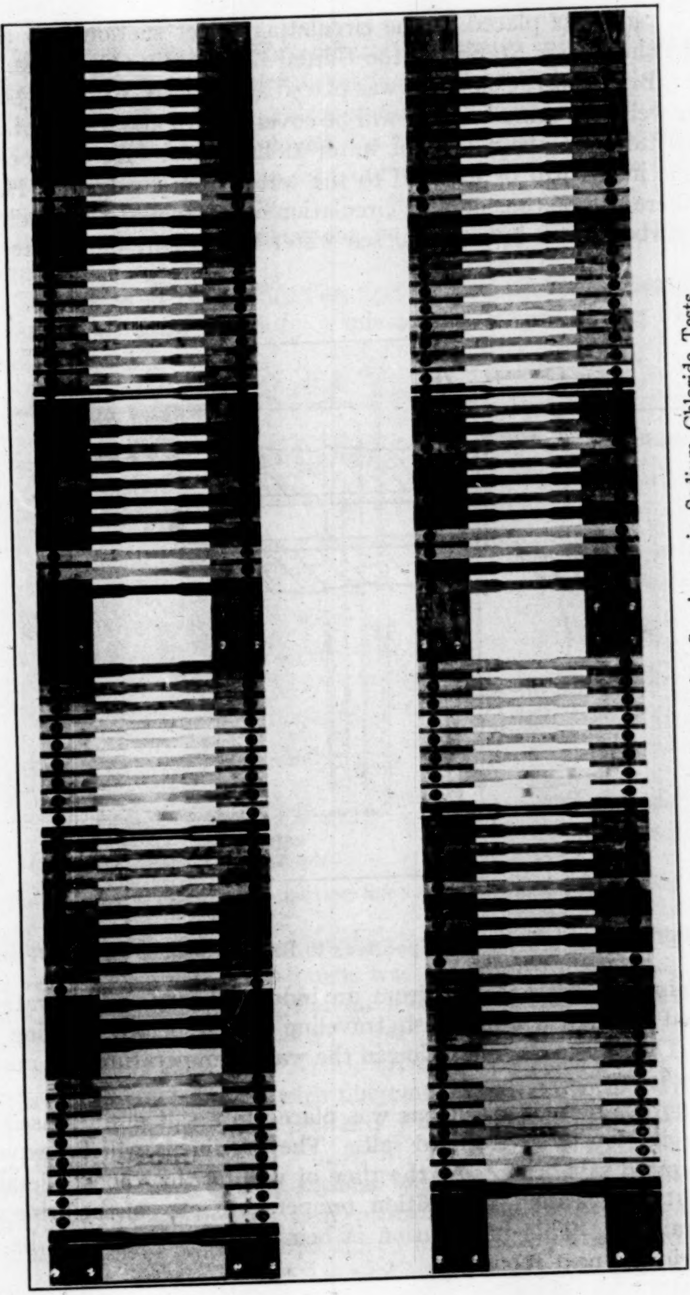


FIG. 1.—Rack Used for Supporting Specimens in Sodium Chloride Tests.

A rack was placed in the circulating water suction well at the Steel Point Power Station of the United Illuminating Co., East Main Street, Bridgeport, Conn. It was placed about 15 ft. from the bottom of the well at a point where it will be covered with about 3 ft. of water at low tide and about 9 ft. of water at high tide. At this location, the specimens will be exposed to the water from Bridgeport Harbor and there will be considerable circulation of water past the specimens. The harbor water is a typical sea water with slight but appreciable contamination with sewage from an industrial city. The water is screened through a ½-in. mesh traveling screen before entering the well. The day-to-day variation in the water temperature is a matter of record.

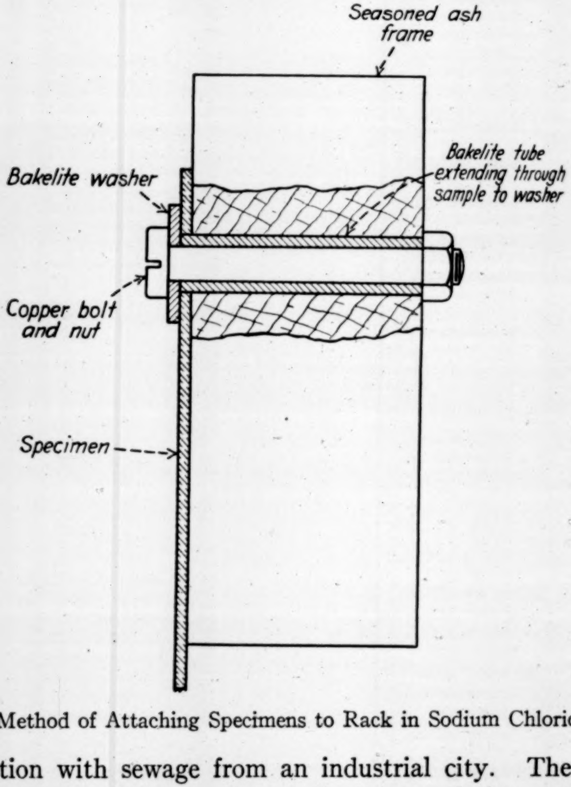


FIG. 2.—Method of Attaching Specimens to Rack in Sodium Chloride Tests.

Another rack of specimens was placed in a salt grainer used for the production of crystallized salt. The specimens will be exposed to saturated salt brine. At the time of writing this report, detailed information regarding composition, temperature, etc., of the brine was not available. This information is being obtained and will be reported in the next report.

Sodium Hydroxide:

Mr. L. F. Marek, Massachusetts Institute of Technology, is chairman of Section 2, which is testing the metals A, D, H, J, L, M, N, P, Q, R, S, T, and W against sodium hydroxide solutions as they occur in evaporators employed for the commercial production of electrolytic caustic soda and for the recovery of alkali from the black liquor of sulfate paper mills.

Before placing the specimens in test, each one was measured, cleaned and weighed.

The width of the reduced section of specimens was measured to ±0.001 in. at three places by a micrometer caliper having flat faces and recorded as the average of the three readings. The thickness of the reduced section of specimens was measured to ±0.0002 in. by a micrometer caliper having flat faces and recorded as the average of the three readings.

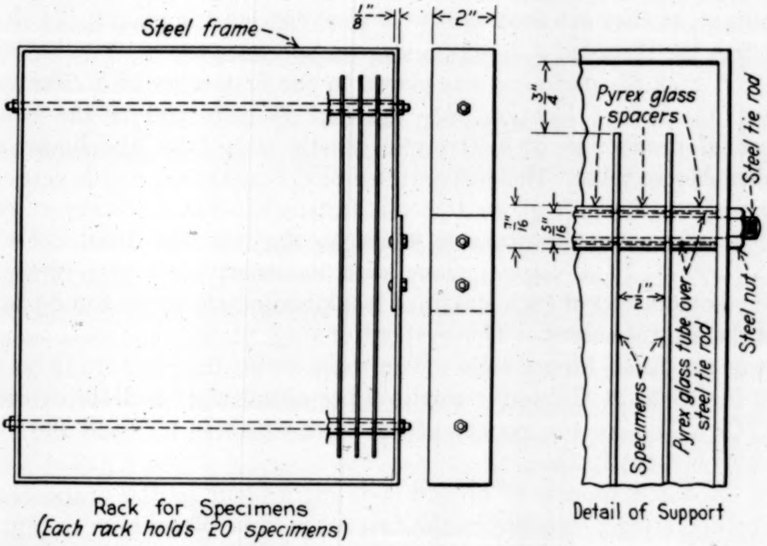

Steel frame
1/8"
2"
3/4"
Pyrex glass spacers
Steel tie rod
7/16"
5/16"
1/2"
Steel nut
Specimens
Pyrex glass tube over steel tie rod
Rack for Specimens
(Each rack holds 20 specimens)
Detail of Support

FIG. 3.—Rack Used for Supporting Specimens in Sodium Hydroxide Tests.

Specimens of metals A, D, H, and N were pickled in dilute hydrochloric acid, buffed with fine emery, washed with water, rinsed with alcohol, dried, and polished with a dry, clean cotton cloth. Specimens of metals J, P, L, S, M, R, and Q were buffed with a motor-driven wire brush, washed with water, rinsed with alcohol, dried, and polished with a dry, clean cotton cloth. Specimens of metals T and W were washed, rinsed with alcohol, dried, and polished with a dry, clean cotton cloth. After cleaning, all specimens had bright, clean, smooth surfaces with the exception of the specimens of metal J. The J specimens had a rough or matte surface and were not ground down to a smooth, polished surface. The J specimens were thoroughly cleaned, however, by buffing and washing.

All specimens were weighed on a chainomatic balance to 0.1 mg. The accuracy of weighing was probably within ±0.5 mg., possible inaccuracies being due to moisture condensation on specimens, variations in weights, imperfect cleaning, etc.

The weighed specimens were mounted in racks constructed of steel flats as shown in Fig. 3. Threaded steel rods are used to support the specimens. As Fig. 3 shows, the specimens are not in electrical contact, as they are separated with glass spacers and glass tubes that sheath the threaded rods supporting the specimens.

A rack of specimens was placed in the first effect of a Zaremba evaporator (test location No. 13) that is employed in the commercial production of electrolytic caustic soda from the liquor of Allen Moore cells. The evaporator is of the basket-type with vertical tubes, and the rack of specimens is fastened to the downtake at the point where the downtake is joined to the top tube sheet. Each specimen is in a vertical plane with its longitudinal axis vertical. The bottom end of each specimen is approximately in the same plane as the top tube sheet. This evaporator stage receives the weak liquor from the Allen Moore cells. The weak liquor temperature is 60 to 70 F. (15 to 21 C.) and it carries 9 per cent NaOH and 16 per cent NaCl. The specific gravity of the weak liquor is 1.23 and the viscosity is 4 centipoises.

A batch process of operation is carried out in the evaporator. The operating procedure in the first stage is to fill with weak liquor and concentrate by boiling under substantially atmospheric pressure. The concentrated liquor is withdrawn as required by the second stage, and the liquid in the first stage is made up with fresh additions of weak liquor from the cells. The evaporator usually operates about 5 hr. per day for 6 days per week. When concentrated in this manner, the liquor temperature ranges between 216 and 227 F. (102 and 108 C.) and the liquor composition increases from 9 to 19 per cent NaOH and from 16 to 12 per cent NaCl. The velocity with which the liquid moves over the specimens is not known definitely, but it is believed to range between 1½ and 3 ft. per sec. The liquor withdrawn from the first effect has a specific gravity of 1.3 and a viscosity of 1.0 centipoises.

Another rack of specimens was placed in the second effect of the Zaremba evaporator (test location No. 11) that has been described, and the rack is mounted at the same point and in the same manner as in the first effect or test location No. 13.

The operating procedure in the second stage is to start by filling with weak liquor from the Allen Moore cells and concentrate under reduced pressure. As concentration proceeds, the batch is made up as required by drawing liquor from the first stage described above. The salt crystals that separate from the liquor during concentration are removed by an external filter. When concentrated in this manner, the liquor temperature ranges between 160 and 180 F. (71 and 82 C.) and the liquor composition changes from 10 to 50 per cent NaOH and from 16 to 5 per cent NaCl. The liquid velocity is believed to range between $1\frac{1}{2}$ and 3 ft. per sec., and the liquid probably contains very little dissolved oxygen or other gases. The liquor withdrawn from the second effect has a specific gravity of 1.48 and a viscosity of 6 centipoises.

A third rack of specimens was placed in the first effect of a Swenson multiple effect evaporator (test location No. 12) employed to concentrate the black liquor resulting from the digestion of aspen wood with the caustic soda obtained by evaporation of cell liquors in a manner similar to that employed at test location No. 13. The evaporator is of the horizontal tube type in which the steam passes through a bank of tubes submerged in the liquor. The rack is wired flat to the top layer of tubes. Thus, each sample is in a vertical plane with the long axis horizontal, and the liquid and vapors flow upwards between the specimens.

The black liquor fed to the first effect is at a temperature of 176 F. (80 C.) and it carries 5 per cent NaOH combined with 15 per cent organic matter and 0.5 per cent NaCl. The specific gravity of the liquor received is 1.08 and its viscosity is 1.0 at 176 F. (80 C.).

The evaporator operates in a continuous manner and the operating procedure is to fill the evaporator with black liquor and concentrate by boiling at a pressure of about atmospheric and a temperature of about 215 F. (102 C.). The velocity of liquid flow past the specimens is believed to be between 0.5 and 1.0 ft. per sec., and the liquid is thought to contain very little dissolved gases of any kind. The black liquor is fed continuously to the evaporator at an appropriate rate, and the concentrated liquor is pumped to the second stage in a similar manner. The liquor withdrawn from the first stage carries 7 per cent NaOH combined with 21 per cent organic matter and 0.7 per cent NaCl, and its specific gravity is 1.1 and its viscosity is 1.2 centipoises.

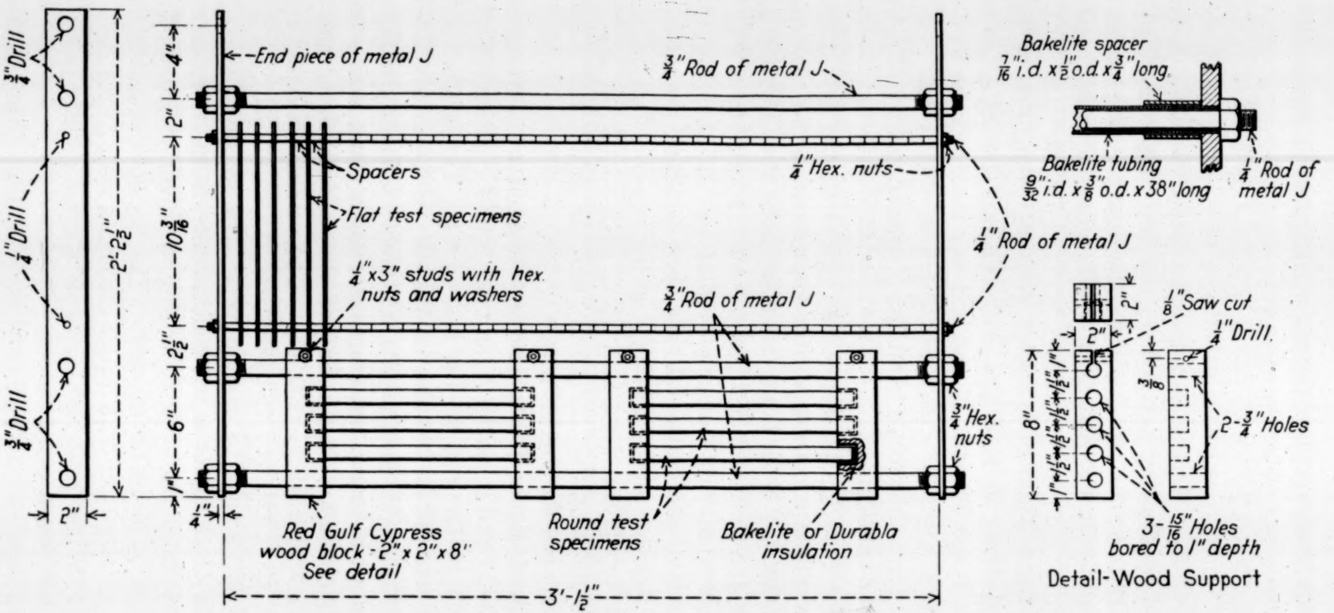

$\frac{3}{4}$" Drill
$\frac{1}{4}$" Drill
$\frac{3}{4}$" Drill
2"
2'-2$\frac{1}{2}$"
4"
2"
10$\frac{3}{16}$"
2$\frac{1}{2}$"
6"
1"
$\frac{1}{4}$"
End piece of metal J
$\frac{3}{4}$" Rod of metal J
Spacers
Flat test specimens
$\frac{1}{4}$" x 3" studs with hex. nuts and washers
$\frac{1}{4}$" Hex. nuts
$\frac{1}{4}$" Rod of metal J
$\frac{3}{4}$" Rod of metal J
$\frac{3}{4}$" Hex. nuts
Red Gulf Cypress wood block - 2" x 2" x 8" See detail
Round test specimens
Bakelite or Durabla insulation
3'-1$\frac{1}{2}$"
Bakelite spacer
$\frac{7}{16}$" i.d. x $\frac{1}{2}$" o.d. x $\frac{3}{4}$" long
Bakelite tubing
$\frac{9}{32}$" i.d. x $\frac{3}{8}$" o.d. x 38" long
$\frac{1}{4}$" Rod of metal J
2"
2"
$\frac{1}{8}$" Saw cut
$\frac{1}{4}$" Drill.
8"
1"
1$\frac{1}{2}$"
$\frac{3}{8}$
2-$\frac{3}{4}$" Holes
3-$\frac{15}{16}$" Holes bored to 1" depth
Detail-Wood Support

FIG. 4.—Rack Used for Supporting Specimens in Sulfuric Acid Tests.

Sulfuric Acid:

Mr. W. H. Scott, The Duriron Co., Inc., is chairman of Section 4, which is testing the metals A, C, D, H, J, K, L, M, N, P, Q, R, S, T, U, X, and Y against sulfuric acid solutions as they occur in equipment used to pickle steel during its commercial production.

The section has completed weight loss determinations on 315 specimens and tension tests on 162 of the corroded specimens. Three series of specimens, namely, series A, B, and C have been exposed successively at test location No. 31 and two series at test locations Nos. 32 and 33. The data obtained from these various tests appear in Tables I to IV. The values given represent the average of the results obtained on three separate specimens, except where otherwise noted.

Before any specimen was placed in test, it was accurately measured and weighed. The areas of the flat specimens were determined by laying out the contour on a drawing board, and calculating the area by triangulation and checking with Simpson's Rule. The cast specimen areas were determined by dividing the specimen into cylinders and cone frustrums. All readings were taken to the nearest 0.1 mm. After changing to square decimeters, the decimal was carried out to two significant figures. Sheet samples were weighed to the nearest 0.1 mg. and cast samples to the nearest 0.1 g. After testing, the specimens were cleaned by brushing with a medium wire brush.

The weighed specimens were supported in racks which were placed in the acid. The type of rack used in series A tests at locations Nos. 31, 32, and 33, and in series B tests at location No. 31, is illustrated in Figs. 3 and 4 of the 1932 report.[1] In subsequent tests, the specimens were supported in the improved rack illustrated in Fig. 4. The metal parts of the rack are of the metal J and the wood parts are of Red Gulf Cypress. A bakelite tube was slipped over the metal rod holding the specimens, and the specimens were insulated from each other by bakelite separators in the form of nipples, in the manner shown in Fig. 4.

At test location No. 31, three racks of specimens have been exposed successively for periods of 132, 92, and 42 days, respectively, as follows:

Series A.—Test started January 22, 1932, and completed June 3, 1932
Series B.—Test started June 5, 1932, and completed September 6, 1932
Series C.—Test started June 24, 1933, and completed August 5, 1933

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 244 and 245 (1932).

TABLE I.—AVERAGE CORROSION RATE AND CHANGE OF PHYSICAL PROPERTIES OF THREE SETS OF SPECIMENS EXPOSED TO SULFURIC ACID FOR THE TIME SHOWN AT THE LOCATION SHOWN.

Identification Letter	Material	Change in Weight, g.	Average Breaking Strength, lb.	Average Elongation in 2 in., per cent	Corrosion Rate, mg. per sq. dm. per day	Percentage Change		Change of Elongation[a]
						Breaking Strength	Elongation	
SERIES A. TEST LOCATION NO. 31. EXPOSED 144 DAYS.								
A	Commercial Copper (Tough Pitch)	−13.6901	343	38.0	90	−39.0	−13.6	−6.0
C	Cu-Si-Mn Alloy (96 Cu, 3 Si, 1 Mn)	−11.6782	647	55.0	77	−37.0	−5.2	−3.0
D	Tin Bronze (92 Cu, 8 Sn)	−12.7116	642	63.5	84	−36.0	−8.0	−5.5
H	Aluminum Bronze	−11.4820	261	1.3[b]	76	−82.0	−95.0	−20.7
J	Low-Carbon Ni-Cr-Fe (22 Ni, 20 Cr, bal. Fe)	−0.9290	1644	54.8[c]	6	nil	+113.0	+29.0
K[d]	Manganese Bronze	......	....	....	..	......	......	......
L	Brass (85 Cu, 15 Zn)	−13.7440	403	36.0	91	−43.5	−12.0	−5.0
M	Brass (70 Cu, 30 Zn)	−13.5582	476	49.0	89	−44.0	−7.5	−4.0
N	Admiralty Metal (70 Cu, 29 Zn, 1 Sn)	−12.6026	539	47.5	83	−40.8	−nil	−nil
P	Cu-Ni-Zn Alloy (75 Cu, 20 Ni, 5 Zn)	−10.6070	668	30.5	69	−29.6	−6.2	−2.0
Q	Cu-Ni-Sn Alloy (70 Cu, 29 Ni, 1 Sn)	−10.3798	836	24.2	68	−33.6	−nil	−nil
R	Cupro Nickel (83 Cu, 17 Ni)	−11.4901	571	31.0	76	−36.0	−nil	−nil
S	Nickel-Copper Alloy (70 Ni, 30 Cu)	−9.3564	1056	37.5	61	−18.9	−nil	−nil
T	Commercial Nickel (99+ per cent Pure)	−13.3143	728	17.5[b]	88	−41.0	−51.5	−18.5
U	Chemical Lead (0.06 Cu)	−10.8089	25[e]	25.3[e]	71	−44.0	−42.0	−18.3
X	Silicon Cast Iron	−3.1666	2723[f]	nil	13	−13.2	....	......
Y	Leaded Bronze (75 Cu, 10 Sn, 15 Pb)	−20.8000	6030	13.5[g]	84	−3.8	+11.6	+1.4
SERIES A. TEST LOCATION NO. 32. EXPOSED 102 DAYS.[h]								
J	Low-Carbon Ni-Cr-Fe (22 Ni, 20 Cr, bal. Fe)	−8.5773	1250	40.0	80	−24.0	+54.0	+14.2
X	Silicon Cast Iron	−22.6000	3828[i]	nil	141	+22.0	....	......
Y	Leaded Bronze (75 Cu, 10 Sn, 15 Pb)	−102.3000	4683	9.8[g]	636	−25.3	−19.0	−2.3
SERIES A. TEST LOCATION NO. 33. EXPOSED 37 DAYS.								
A	Commercial Copper (Tough Pitch)	−13.7511	316	38.5	353	−43.5	−12.5	−5.5
C	Cu-Si-Mn Alloy (96 Cu, 3 Si, 1 Mn)	−10.8524	628	57.0	278	−37.4	−nil	−nil
D	Tin Bronze (92 Cu, 8 Sn)	−13.8715	600	64.3	356	−40.2	−7.2	−5.0
H	Aluminum Bronze	−7.6833	722[j]	2.5	197	−50.7	−88.5	−19.5
J	Low-Carbon Ni-Cr-Fe (22 Ni, 20 Cr, bal. Fe)	−0.7345	1530	23.0[c]	19	−6.9	−11.0	−2.8
K	Manganese Bronze	−4.1203	624	0.3[b]	105	−73.4	−96.5	−7.7
L	Brass (85 Cu, 15 Zn)	−11.2185	443	40.2	288	−38.0	−nil	−nil
M	Brass (70 Cu, 30 Zn)	−10.2429	257[k]	6.3[b]	263	−70.0	−88.0	−46.6
N	Admiralty Metal (70 Cu, 29 Zn, 1 Sn)	−10.7516	572	50.8	276	−37.2	+5.8	+2.8
P	Cu-Ni-Zn Alloy (75 Cu, 20 Ni, 5 Zn)	−10.2660	665	31.2	263	−30.0	−4.0	−1.3
Q	Cu-Ni-Sn Alloy (70 Cu, 29 Ni, 1 Sn)	−13.5450	706	23.8	348	−44.0	−4.8	−1.2
R	Cupro Nickel (83 Cu, 17 Ni)	−11.9460	532	30.5	306	−40.2	−nil	−nil
S	Nickel-Copper Alloy (70 Ni, 30 Cu)	−7.9483	1085	36.0	204	−16.6	−3.0	−1.0
T	Commercial Nickel (99+ per cent Pure)	−7.2722	1051	35.8	187	−15.0	−nil	−nil
U	Chemical Lead (0.06 Cu)	−0.1249	39[e]	31.8[e]	3	−14.6	−27.0	−11.8
X	Silicon Cast Iron	−1.3000	2058[f]	nil	20	−34.4	....	......
Y	Leaded Bronze (75 Cu, 10 Sn, 15 Pb)	−16.5666	6283	13.8[g]	258	nil	+14.0	+1.7

[a] This is the change from the original elongation. It is not a percentage change of the percentage elongation in 2 in.

[b] One corroded specimen broke outside elongation marks.

[c] One blank specimen broke outside elongation marks.

[d] Lost.

[e] Original breaking strength and elongation estimated from 1932 report of Committee B-3 as 45.3 lb. and 43.6 per cent, respectively.

[f] One blank specimen broke in grips earlier.

[g] Two corroded specimens broke outside elongation marks.

[h] In this test the rack was destroyed under the violent agitation in the continuous pickler and all the samples were lost in the bottom of the 6-ft. tank and could not be recovered until the tank was drained. All of the specimens. with the exception of the above, were either dissolved or otherwise lost.

[i] One blank and one corroded specimen broke in grips earlier.

[j] One corroded specimen was broken.

[k] One corroded specimen broke in grips earlier.

The racks were placed in the tank of a Grey pickler, being supported by rods of the metal J attached to the wooden frame at one end. When supported in this manner, the specimens were in a vertical position and completely submerged in the acid, except for short periods when the tank was being emptied and refilled with fresh acid.

The pickle used in the tank carried 0.5 to 4 per cent sulfuric acid, by weight. The procedure was to make up fresh acid to a concentration of 4 per cent and pickle at 200 F. (93 C.), heating being accomplished by injecting live steam. The acid concentration was maintained by adding 60° Baumé sulfuric acid in appropriate quantities as required. The ferrous sulfate content of the pickle increased gradually with use until it reached about 17 per cent, when further acid additions were made. Hydrogen was evolved during pickling which saturated the pickle with this gas. Then the pickle temperature was raised to a maximum of 212 F. (100 C.) to compensate

TABLE II.—AVERAGE CORROSION RATE AND CHANGE OF PHYSICAL PROPERTIES OF THREE SETS OF SPECIMENS EXPOSED TO SULFURIC ACID FOR 92 DAYS AT TEST LOCATION NO. 31.

SERIES B. TEST LOCATION NO. 31. EXPOSED 92 DAYS.

Identification Letter	Material	Change in Weight, g.	Average Breaking Strength, lb.	Average Elongation in 2 in., per cent	Corrosion Rate, mg. per sq. dm. per day	Percentage Change		Change of Elongation[a]
						Breaking Strength	Elongation	
A	Commercial Copper (Tough Pitch)	−6.6950	448	42.3	69	−20.0	−3.6	−1.6
C	Cu-Si-Mn Alloy (96 Cu, 3 Si, 1 Mn)	−5.9744	790	58.5	62	−21.2	nil	+0.5
D	Tin Bronze (92 Cu, 8 Sn)	−5.9592	811	67.5	62	−19.1	−2.2	−1.5
H	Aluminum Bronze	−5.1761	810	2.8	54	−44.6	−88.0	−19.2
J	Low-Carbon Ni-Cr-Fe (22 Ni, 20 Cr, bal. Fe)	−0.7651	1696	50.0[b]	8	+3.2	+94.0	+23.0
K	Manganese Bronze	−6.2724	813	0.8	65	−65.3	−90.0	−7.2
L	Brass (85 Cu, 15 Zn)	−6.4940	560	41.0	67	−21.5	nil	+0.3
M	Brass (70 Cu, 30 Zn)	−6.2741	672	57.3	65	−21.1	+8.1	+4.3
N	Admiralty Metal (70 Cu, 29 Zn, 1 Sn)	−6.5729	710	51.8	68	−22.1	+7.9	+3.8
P	Cu-Ni-Zn Alloy (75 Cu, 20 Ni, 5 Zn)	−4.9804	804	29.2	52	−15.3	−10.0	−3.3
Q	Cu-Ni-Sn Alloy (70 Cu, 29 Ni, 1 Sn)	−5.0340	1072	24.2	52	−15.0	−4.0	−0.8
R	Cupro Nickel (83 Cu, 17 Ni)	−5.3963	718	31.0	56	−19.4	nil	−0.1
S	Nickel-Copper Alloy (70 Ni, 30 Cu)	−4.8096	1209	36.2	50	−7.1	−2.2	−0.8
T	Commercial Nickel (99+ per cent Pure)	−7.1722	1064	25.7[c]	74	−13.8	−29.0	−10.3
U	Chemical Lead (0.06 Cu)	−5.1058	34[d]	29.0[d]	53	−24.5	−33.5	−14.6
X	Silicon Cast Iron	−2.1666	3555	nil	14	+13.3	......	......
Y	Leaded Bronze (75 Cu, 10 Sn, 15 Pb)	−11.0000	6732	17.0	70	+22.1	+41.5	+5.0

[a] This is the change from the original elongation. It is not a percentage change of the percentage elongation in 2 in.

[b] One blank specimen broke outside elongation marks.

[c] One corroded specimen broke outside elongation marks.

[d] Original breaking strength and elongation estimated from 1932 report of Committee B-3 as 45.3 lb. and 43.6 per cent, respectively.

for diminishing acidity, and when the acidity decreased to 0.5 per cent, the pickle was run to waste and a new batch made up. The pickle bath temperature was maintained above 200 F. (93 C.) for approximately 10 hr. per day, and the pickler was operated usually for 10 hr. per day for 5 days per week in series A test; in series B and C, for 10 hr. per day, 7 days per week. When the pickler was in operation, the pickle liquor was agitated almost constantly by the up-and-down movement (20 strokes per minute) of the steel being pickled. When not in operation, the pickle liquor was permitted to cool until 2 hr. before beginning operations again, when reheating was begun. The pickler was in operation for approximately 50 per cent of the whole period of exposure for series A tests, 40 per cent for series B, and 100 per cent for series C.

TABLE III.—AVERAGE CHANGE OF WEIGHT AND CORROSION RATE OF THREE SETS OF SPECIMENS EXPOSED TO SULFURIC ACID FOR 42 DAYS AT THE TEST LOCATIONS INDICATED.

Identification Letter	Material	Series B				Series C	
		Test Location No. 32		Test Location No. 33		Test Location No. 31	
		Change in Weight, g.	Corrosion Rate, mg. per sq. dm. per day	Change in Weight, g.	Corrosion Rate, mg. per sq. dm. per day	Change in Weight, g.	Corrosion Rate, mg. per sq. dm. per day
A	Commercial Copper (Tough Pitch)	[a]	...	−16.7527	378	−17.0030	386
C	Cu-Si-Mn Alloy (96 Cu, 3 Si, 1 Mn)	−26.8104	607	−17.3587	394	−19.4753	442
D	Tin Bronze (92 Cu, 8 Sn)	−30.6040	695	−21.4877	488	−27.0560	615
H	Aluminum Bronze	[a]	...	−13.1250	298	−18.9285	430
J	Low-Carbon Ni-Cr-Fe (22 Ni, 20 Cr, bal. Fe)	−9.4348	214	−0.4143	9	+0.0008	...
K	Manganese Bronze	[a]	...	[a]	...	[a]	...
L	Brass (85 Cu, 15 Zn)	−27.3701	620	−18.3560	417	−18.9378	430
M	Brass (70 Cu, 30 Zn)	[a]	...	−20.1303	457	−18.4715	418
N	Admiralty Metal (70 Cu, 29 Zn, 1 Sn)	[a]	...	−18.2293	414	−14.9670	340
P	Cu-Ni-Zn Alloy (75 Cu, 20 Ni, 5 Zn)	−24.7540	560	−16.5372	376	−32.2556	733
Q	Cu-Ni-Sn Alloy (70 Cu, 29 Ni, 1 Sn)	−21.6635	490	−16.6398	378	−29.5502	670
R	Cupro Nickel (83 Cu, 17 Ni)	−25.0005	565	−18.7341	425	−32.5564	737
S	Nickel-Copper Alloy (70 Ni, 30 Cu)	−21.6360	490	−15.5625	353	−26.0989	592
T	Commercial Nickel (99+ per cent Pure)	−26.4028	600	−18.4782	420	[a]	...
U	Chemical Lead (0.06 Cu)	[a]	...	+0.0127	...	−6.0617	137
X	Silicon Cast Iron	−4.6000	63	−10.8000	150	−1.3000	18
Y	Leaded Bronze (75 Cu, 10 Sn, 15 Pb)	−37.3000	515	−35.3000	487	−52.4000	723

[a] Lost.

At test location No. 32, two racks of specimens have been exposed successively for periods of 168 and 42 days, respectively, as follows:

Series A.—Test started February 26, 1932, completed August 13, 1932
Series B.—Test started June 24, 1933, completed August 5, 1933

The racks were placed in the tank of a large continuous pickler. The tank measured 12 ft. 6 in. in width by 4 ft. 6 in. in depth by 90 ft. in length, and the rack was located in series A at the entrance end of the tank and in series B at the exit end. When supported in this manner, the specimens were in a vertical position and completely submerged in the acid, except for short periods when the tank was being emptied and refilled with fresh acid.

The pickle used in the tank carried 3.5 to 10 per cent sulfuric acid, by weight. The procedure was to make up fresh acid to a concentration of 10 per cent and pickle at 155 F. (68 C.). Heating was accomplished by live steam introduced through perforated pipes located at the entrance end of the tank. The acid concentration was maintained by adding 78 per cent sulfuric acid in appropriate quantities as required. The ferrous sulfate content of the pickle increased gradually with use, and when the ferrous sulfate content reached 17.50 per cent no further acid additions were made. Thereafter, the pickling temperature was raised gradually to a maximum of 185 F. (85 C.) to compensate for diminished acidity until the acidity had decreased to 3.5 per cent, when the pickle was run to waste and a new batch made up. The specific gravity of the pickle liquor increased from 1.05 to 1.25. The continuous pickler was operated usually as follows: for series A, 4 to 24 hr. per day, 6 days per week; for series B, 10 to 20 hr. per day, 6 days per week. When in operation, the pickle liquor was agitated gently by the movement of steel sheets through the pickle liquor. The sheets, which were in a vertical plane, moved horizontally through the solution at a rate of 9 ft. per min. Hydrogen was evolved during pickling which saturated the pickle liquor with this gas. When the pickler was not in operation, the

TABLE IV.—PHYSICAL PROPERTIES OF UNEXPOSED SPECIMENS AS DETERMINED AT SAME TIME AS FOR CORRODED SPECIMENS.

Identification Letter	Material	Thickness, in.	Breaking Strength, lb.	Tensile Strength, lb. per sq. in.	Elongation in 2 in., per cent
A	Commercial Copper (Tough Pitch)	0.034	561	33 000	44.0
C	Cu-Si-Mn Alloy (96 Cu, 3 Si, 1 Mn)	0.034	1002	59 000	58.0
D	Tin Bronze (92 Cu, 8 Sn)	0.034	1002	59 000	69.0
H	Aluminum Bronze	0.032	1463	91 600	22.0
J	Low-Carbon Ni-Cr-Fe (22 Ni, 20 Cr, bal. Fe)	0.040	1643	82 400	25.8
K	Manganese Bronze	0.037	2345	127 000	8.0
L	Brass (85 Cu, 15 Zn)	0.035	714	40 800	41.0
M	Brass (70 Cu, 30 Zn)	0.035	852	48 700	53.0
N	Admiralty Metal (70 Cu, 29 Zn, 1 Sn)	0.034	911	53 600	48.0
P	Cu-Ni-Zn Alloy (75 Cu, 20 Ni, 5 Zn)	0.036	949	52 700	32.5
Q	Cu-Ni-Sn Alloy (70 Cu, 29 Ni, 1 Sn)	0.034	1260	74 100	25.0
R	Cupro Nickel (83 Cu, 17 Ni)	0.035	891	50 900	30.8
S	Nickel-Copper Alloy (70 Ni, 30 Cu)	0.034	1302	76 500	37.0
T	Commercial Nickel (99+ per cent Pure)	0.034	1235	72 600	36.0
U	Chemical Lead (0.06 Cu)	0.035	45[a]	2 580[a]	43.6[a]
X	Silicon Cast Iron	0.505	3138	15 700	nil
Y	Leaded Bronze (75 Cu, 10 Sn, 15 Pb)	0.505	6267	31 300	12.1

[a] Values estimated from the 1932 Report of Committee B-3, see *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 221 (1932).

liquor was permitted to cool until 1½ hr. before beginning operations again, when reheating was begun. The pickler was in operation for approximately 25 per cent of the whole period of exposure for the series A tests and 50 per cent for series B.

At test location No. 33, two racks of specimens have been exposed successively for periods of 36 and 42 days, respectively, as follows:

Series A.—Test started June 2, 1932, completed July 8, 1932
Series B.—Test started June 24, 1933, completed August 5, 1933

The racks were placed in an open batch type pickler 3 ft. by 33 ft. heated by a steam jet at each end in opposite corners, rack placed across one end. When supported in this manner, the specimens were in a vertical position and completely submerged in the acid, except for short periods when the tank was being emptied and refilled with fresh acid.

The pickle used in the tank carried 4 per cent sulfuric acid, by weight. An inhibitor (Rodine) was employed. The procedure was to make up fresh acid to a concentration of 4 per cent and then add one quart of inhibitor for every 14 gal. of pickle liquor. Pickling was done at 160 F. (71 C.), heating being accomplished by injecting steam at 15-lb. pressure. The acid concentration was maintained by adding 78 per cent sulfuric acid in appropriate quantities as required. The ferrous sulfate content of the pickle increased gradually with use until the pickle was run to waste and a new batch made up. The pickling equipment was operating usually for 10 hr. per day for 6 days per week. When the pickler was in operation, the pickle liquor was agitated almost constantly by circulating steam jets. Hydrogen was evolved during the pickling which saturated the pickle liquor with this gas. When not in operation, the pickle liquor was permitted to cool until 4 hr. before beginning operations again, when reheating was begun. The pickling equipment was in operation for approximately full time for the series A tests and half time for series B.

Although the work of Subcommittee VII is far from complete, sufficient data have been provided to enable other subcommittees of Committee B-3 to resume their efforts in developing laboratory corrosion tests.

It will be apparent from an examination of the data presented that there is considerable variation in the corrosive action of pickle liquors as they are used in practice. This is particularly evident when comparing the data from test location No. 32 with the data from test location No. 31. Therefore, careful attention must be given to the duplication of practical conditions when conducting laboratory corrosion tests, and this must be provided for in any standardized laboratory corrosion test that may be developed.

Also, it is apparent from an examination of the data that no one method of measuring corrosion rate is satisfactory; for example, at test location No. 33 the specimens of metal K did not show a high rate of corrosion when measured in terms of weight lost, but in terms of loss in strength and elongation the corrosion was very great. This particular metal suffered disintegration that was much greater in proportion than any change of weight or dimensions. The appearance of the corroded specimen was not materially different than before testing, except for a change in color, which was of a more coppery nature. Dezincification had taken place. A further example is the case of metal T at test location No. 31. This metal suffered a considerable loss in percentage elongation as compared with metal R, whereas, the weight loss suffered by the two metals was of the same order. Pitting had occurred on metal T while metal R had corroded uniformly.

These examples suffice to show that the measurement of corrosion involves changes of weight, physical properties, and the nature of corrosion, that is, whether uniform or localized. Therefore, in any standardized laboratory corrosion test provision must be made to measure changes in these factors and to express them in some simple manner.

From the data available now, it appears that some group of metals might be arranged according to corrosion resistance in almost any order by an experimenter who was privileged to manipulate the test conditions and to select some one unit of measure, such as change of tensile strength. The fact that various arrangements may be obtained from the same group of metals when an experimenter is given latitude, stresses the importance of defining with adequacy and precision the methods to be followed in making a standardized corrosion test and in measuring the results. Obviously, standardized laboratory corrosion testing is not a matter to be taken lightly when the probable performance of materials in service is to be predicted with accuracy.

Respectfully submitted on behalf of the subcommittee,

R. J. McKAY,
Chairman.

REPORT OF SUBCOMMITTEE VIII ON GALVANIC AND ELECTROLYTIC CORROSION

The test program of Subcommittee VIII covers a study of the effect of galvanic action on the corrosion behavior of metals when in contact with dissimilar metals. This report is a record of the corrosion which has occurred over the initial 1-yr. period of such a test now under way in outdoor exposure.

All of the couple combinations of the following metals are included in the present investigation:

IDENTIFICATION LETTER	MATERIAL
BB	Zinc (99.0+ per cent)
G	Aluminum (99.1+ per cent)
GG	Iron (mild steel)
T	Nickel (99.3 per cent)
A	Copper (99.9+ per cent)
EE	Tin (99.8+ per cent)
U	Lead (99.9+ per cent)

The type of test specimen and the manner of coupling is illustrated in Fig. 1. In order to determine the normal rate of corrosion of the metals assembled in this manner, couples consisting of two disks of the same metal were included as "blanks."

The couples were subjected to atmospheric corrosion at the following test locations:

TEST LOCATION	ATMOSPHERE CLASSIFICATION	EXPOSURE PERIOD	ELAPSED TIME DAYS	ELAPSED TIME YEARS
State College, Pa.	rural	June 8, 1931, to June 8, 1932	366	1.00
Phoenix, Ariz.	rural (dry)	Sept. 4, 1931, to Sept. 22, 1932	384	1.05
Sandy Hook, N. J.	Northeastern seacoast	Apr. 14, 1931, to Apr. 14, 1932	366	1.00
Key West, Fla.	Southeastern seacoast	Oct. 12, 1931, to Oct. 12, 1932	366	1.00
La Jolla (San Diego), Calif.	Southwestern seacoast	Sept. 1, 1931, to Sept. 15, 1932	380	1.04
Rochester, N. Y.	industrial (humid)	Sept. 21, 1931, to Sept. 21, 1932	366	1.00
Altoona, Pa.	industrial	June 1, 1931, to June 6, 1932	372	1.02
New York City	industrial (seacoast)	Mar. 23, 1931, to Mar. 23, 1932	366	1.00
Brunot Island, Pittsburgh, Pa.	industrial	July 8, 1931, to June 29, 1932	357	0.98

Information regarding the meteorological conditions at the test locations, metallurgical history of the metals, the preparation of the test couples, and the installation of the tests at the various locations is to be found in the 1932 report of Committee B-3.[1]

INSPECTION OF THE COUPLES

On receipt of the couples from the first few test locations they were dissembled and loosely adhering corrosion products were removed by scrubbing the disks under running tap water with a stiff bristle brush. Some of these disks were weighed but the results appeared meaningless as some showed gains in weight while others showed losses. In many cases, as judged by the color, the corrosion product of one of the disks was adhering to the other with which it had been coupled. Further, in the case of appreciably corroded blanks in which both disks of the couple were of the same metal, the disks varied widely in change of weight. This condition was caused by a variation in the amount of corrosion product remaining on the disks. Consequently, in order to secure data of value, it was necessary to postpone the weighing of the specimens until suitable methods of removing the corrosion products could be developed.

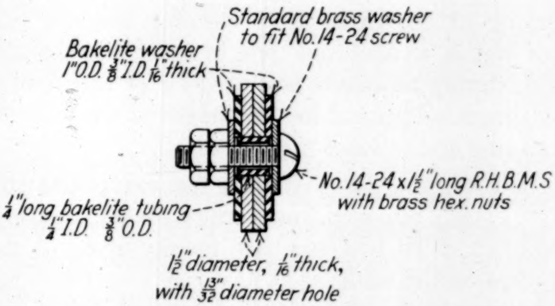

Standard brass washer to fit No. 14-24 screw
Bakelite washer 1" O.D. $\frac{3}{8}$" I.D. $\frac{1}{16}$" thick
No. 14-24 x $1\frac{1}{2}$" long R.H.B.M.S with brass hex. nuts
$\frac{1}{4}$" long bakelite tubing $\frac{1}{4}$" I.D. $\frac{3}{8}$" O.D.
$1\frac{1}{2}$" diameter, $\frac{1}{16}$" thick, with $\frac{13}{32}$" diameter hole

FIG. 1.—A.S.T.M. Galvanic Couple Assembly for Outdoor Exposure Tests.

After the couples had been received from all of the test locations they were dissembled and given a cursory visual inspection by several of the members of the committee, the following facts being recorded:

1. Amount, distribution and color of corrosion products.
2. Condition of metallic contact.
3. Anode noted when apparent.

The detailed information of this inspection is on file with the secretary of Committee B-3.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 214 to 241 and pp. 248 to 251 (1932).

REMOVING CORROSION PRODUCTS

The corrosion products were then removed by the following methods:

Iron.—The corrosion products were removed from the iron disks by immersing them in a solution consisting of HCl (1:1) to which was added 10 g. per liter of inhibitor (Rodine).[1] The temperature of the solution was held at from 15 to 20 C. Five-minute dips, followed by scrubbing, were repeated until all corrosion products were removed except those in deep pits. To remove the remaining rust, the disks were dried and heated to a dull red heat in an electric furnace for 30 min. in an atmosphere of nitrogen. After the furnace had cooled, the disks were removed and reimmersed in the HCl solution for a period of 10 min. This procedure, followed by a final scrubbing under running water, removed the remaining corrosion products.

The drying of the disks after cleaning was accomplished by rinsing them first in alcohol and then in ether and allowing them to air dry. This drying procedure was used for all metal disks.

The maximum additional loss in weight of the iron disks due to cleaning (cleaning error) was 5 mg. per disk.

Copper, Nickel, and Tin.—With a few exceptions the corrosion products were readily removed from copper, nickel, and tin disks using the same solution of HCl as was used for the iron. A maximum of four 5-min. dips in the solution at 15 to 20 C. were required. The maximum cleaning error was less than 1 mg. per disk.

Lead.—With a few exceptions the corrosion products were removed from the lead disks by a 10-min. immersion at room temperature in the following solution: 15 ml. of concentrated HNO_3 was diluted to 1 liter and 50 g. of oxalic acid was dissolved in this solution. Where iron rust adhered to the lead, the disks were given a 5-min. immersion in the HCl solution. The maximum cleaning error was 6 mg. per disk.

Zinc.—The solution for cleaning zinc disks was prepared as follows: 100 ml. of concentrated H_2SO_4 (sp. gr. 1.86) was diluted to 1 liter. Approximately one-third of this solution was saturated with bichloride of mercury and after filtering was again mixed with the remaining dilute acid. A 1-min. dip in this cleaning solution was sufficient to remove the corrosion products from all zinc disks except those from La Jolla, Calif., which were given a 3-min. dip. The maximum cleaning error was an increase in weight of 3 mg. per disk.

Aluminum.—The aluminum disks were cleaned in the same solution used for the iron disks. The disks were immersed in this solution held at 10 to 12 C. for a period of 10 min. Light hand brushing with a wire brush and careful picking with a steel point while viewing with a microscope at 10 diameters magnification was necessary to remove corrosion products from pits. The maximum cleaning error of this procedure was 4 mg. per disk.

---

[1] Rodine No. 110 obtained from the Am. Chemical Paint Co., Ambler, Pa.

Test Results

After cleaning and drying, the disks were then weighed to determine the losses in weight due to corrosion. The error in weight loss figures due to the method of weighing and the precision of the balance used would amount to approximately ±0.001 g. The results are reported in Table I and shown graphically in Figs. 2 and 3.

In Figs. 2 and 3, the percentage losses in weight of the disks are shown by the height of the columns. All disks of the same metal are grouped together and the respective exposure locations indicated at the bottom of each group. Each disk of the group was coupled with the metal indicated by the chemical symbol over the column. For example, the group marked "Aluminum" show the percentage losses in weight of the aluminum disks when coupled with Al, Cu, Fe, Sn, Zn, Ni, and Pb, respectively. The heavy black line through a group represents the average weight loss of the two disks of the same metal coupled together as a "blank." The percentage loss in weight of the blank is a measure of the normal corrosion rate of this form of specimen of the metal in the respective test exposures. The double cross-hatching is used to mark cases where acceleration of corrosion occurred.

Discussion of Results

An inspection of the results obtained on the present specimens indicates that there is a change in corrosion behavior in the case of some metals when in contact with other metals. The changes are due to galvanic action, complicated by other reactions resulting from the presence of soluble and insoluble corrosion products, differential aeration, concentration cells and other factors. In some instances the disks had been spread apart by the corrosion products and the metal to metal contact apparently broken. That galvanic action alone was not responsible for all of the corrosion that occurred is evidenced by the fact that, in some instances, both metals in the couple showed increased corrosion. From a practical standpoint any composite assembly of metals that approximates the structural assembly of the test specimens such as riveted joints may be expected to behave under similar corrosive conditions in a manner similar to the specimens reported on here. It seems reasonable to assume that the data have some significance, because of the marked changes in

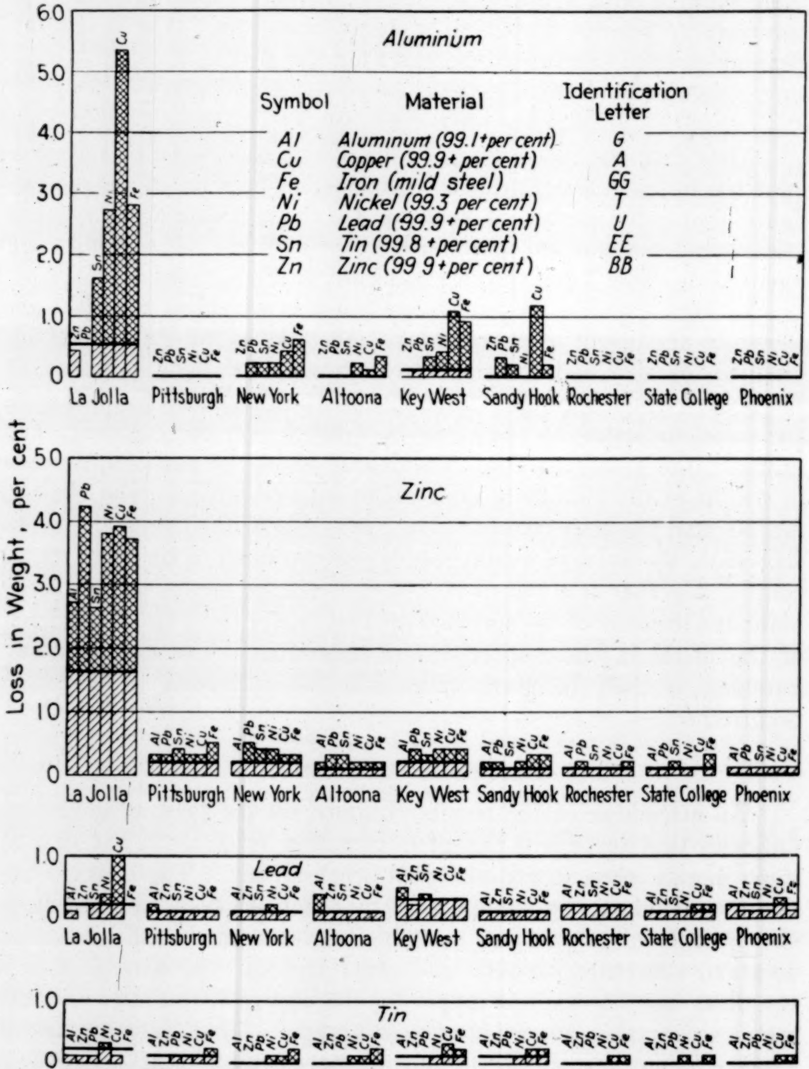


FIG. 2.—Galvanic Couple Corrosion: Percentage Loss in Weight of Aluminum, Zinc, Lead and Tin Disks After One Year of Outdoor Exposure.

corrosion behavior in some instances, and lack of any change in other instances. Consistent behavior of a specific metal in a given type of

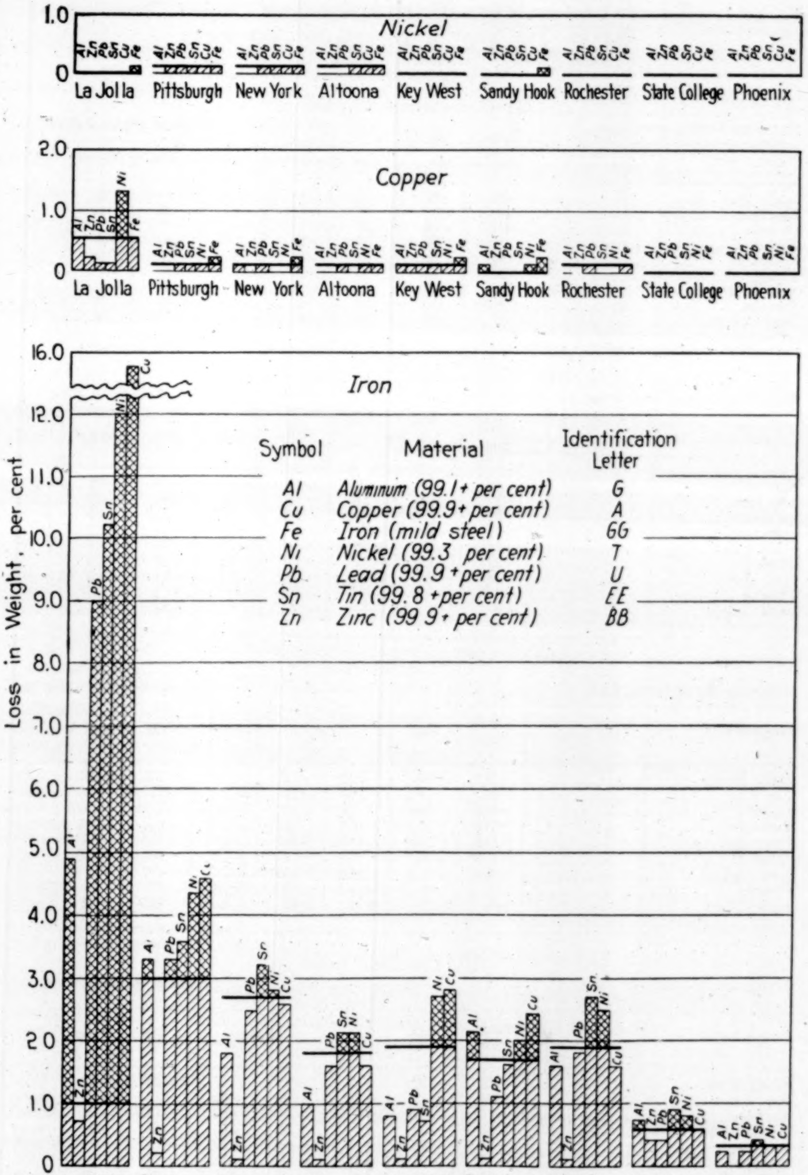


FIG. 3.—Galvanic Couple Corrosion: Percentage Loss in Weight of Nickel, Copper and Iron Disks After One Year of Outdoor Exposure.

Table I.—Weight Loss of Metal Disks in Galvanic Couple Corrosion Test After One Year Exposure, mg. per disk.

Note: ±0.001 g. = precision of weighing.
N = value less than the cleaning error figure.

G: Commercial Aluminum

Maximum cleaning error, 4 mg. Nominal weight of disks, 4.6 g.

Coupled with	Aluminum		Zinc	Iron	Lead	Tin	Nickel	Copper
Sandy Hook	N	N	N	−8	−12	−9	N	−53
Key West	−5	−7	N	−43	−6	−13	−17	−52
La Jolla	−21	−24	−20	−128	....	−71	−122	−244
Rochester	N	N	N	−5	N	N	−5	N
Pittsburgh	N	N	N	N	N	N	N	N
Altoona	N	N	N	−14	N	N	−7	−5
New York	N	N	N	−26	−8	−8	−11	−16
Phoenix	N	N	N	N	N	N	N	N
State College	N	N	N	+5[b], [c]	N	N	N	N

BB: Commercial Zinc (High Grade)

Maximum cleaning error, 3 mg. Nominal weight of disks, 11.9 g.

Coupled with	Aluminum	Zinc		Iron	Lead	Tin	Nickel	Copper
Sandy Hook	−18	−16	−17	−41	−27	−15	−22	−32
Key West	−28	−28	−22	−43	−33	−37	−42	−43
La Jolla[a]	−321	−179	−198	−446	−502	−310	−457	−466
Rochester	−11	−8	−9	−22	−18	−11	−13	−15
Pittsburgh	−32	−23	−20	−61	−40	−43	−41	−37
Altoona	−23	−17	−13	−29	−32	−33	−25	−26
New York	−28	−21	−20	−37	−34	−43	−44	−41
Phoenix	−7	−5	−5	−15	−9	−14	−9	−9
State College	−8	−6	−5	−35	−8	−18	−8	....

GG: Mild Steel

Maximum cleaning error, 5 mg. Nominal weight of disks, 12.8 g.

Coupled with	Aluminum	Zinc	Iron		Lead	Tin	Nickel	Copper
Sandy Hook	−269	−14	−207	−217	−135	−205	−250	−309
Key West	−95	−16	−247	−237	−114	−87	−341	−351
La Jolla[a]	−625	−104	−114	−150	−1144	−1302	−1526	−2020
Rochester	−210	−11	−246	−232	−231	−346	−324	−209
Pittsburgh	−415	−28	−405	−369	−423	−462	−563	−592
Altoona	−137	−12	−234	−219	−199	−268	−270	−207
New York	−230	−9	−345	−338	−325	−411	−359	−328
Phoenix	−29	−4	−43	−40	−29	−53	−38	−33
State College	−82	−45	−71	−69	−55	−115	−98	−74

U: Chemical Lead

Maximum cleaning error, 6 mg. Nominal weight of disks, 19.4 g.

Coupled with	Aluminum	Zinc	Iron	Lead		Tin	Nickel	Copper
Sandy Hook	−13	−10	−18	−30	−17	−19	−21	−25
Key West	−92	−42	−64	−38	−44	−79	−51	−66
La Jolla	−18[b]	−215[b], [d]	+6[b]	−49	−30	−45	−71	−196
Rochester	−33	−29	−44	−29	−43	−47	−32	−40
Pittsburgh	−31	−16	−24	−19	−17	−14	−19	−20
Altoona	−70	−13	−15	−14	−15	−17	−15	−11
New York	−10	−11	N	−15	−13	−19	−35	−16
Phoenix	−30	−16	−22	−51	−23	−28	−26	−50
State College	−19	−17	−36	−19	−32	−28	−17	−30

[a] These disks were corroded under paint on backs.
[b] Corrosion products not completely removed.
[c] No evidence of corrosion observed.
[d] Evidence of mechanical damage.

TABLE I.—*Continued.*

NOTE: ±0.001 g. = precision of weighing.
N = value less than the cleaning error figure.

EE: Commercial Tin

Maximum cleaning error, <1 mg. Nominal weight of disks, 12.3 g.

Coupled with	Aluminum	Zinc	Iron	Lead	Tin		Nickel	Copper
Sandy Hook	N	N	−21	−5	−7	−6	−12	−25
Key West	N	−3	−24	−6	−7	−11	−12	−41
La Jolla	−6	−9	−[a]	−16	−19	−20	−41	−177
Rochester	−4	N	−13	−3	−5	−5	−4	−10
Pittsburgh	−3	−3	−20	−6	−7	−6	−8	−16
Altoona	−5	−4	−19	−4	−4	−6	−8	−16
New York	N	−3	−22	−5	−5	+2	−9	−18
Phoenix	−2	N	−8	N	N	−2	−2	−7
State College	−3	N	−7	−3	−2	−2	−6	−4

T: Commercial Nickel

Maximum cleaning error, <1 mg. Nominal weight of disks, 15 g.

Coupled with	Aluminum	Zinc	Iron	Lead	Tin	Nickel		Copper
Sandy Hook	−3	−2	−9	N	−2	−2	−2	N
Key West	N	N	N	N	+2	N	N	N
La Jolla	−2	−2	−12	N	−2	−2	−3	−2
Rochester	N	+2	−3	N	−3	−3	−4	−2
Pittsburgh	−6	(−14)[b]	−12	−10	−10	−12	−7	−20
Altoona	−3	N	−7	−5	−7	−8	−12	−9
New York	−4	N	−9	−11	−11	−11	−12	−17
Phoenix	N	N	N	N	N	N	N	N
State College	N	−2	N	N	N	N	N	N

A: Commercial Copper (Tough Pitch)

Maximum cleaning error, <1 mg. Nominal weight of disks, 14.9 g.

Coupled with	Aluminum	Zinc	Iron	Lead	Tin	Nickel	Copper	
Sandy Hook	−8	−5	−22	−5	−6	−9	−6	−6
Key West	−8	−8	−26	−7	−20	−10	−10	−9
La Jolla	−33	−24	−67	−19	−15	−186	−62	−84
Rochester	−4	−33[b]	−7	−7	−5	−6	−6	−8
Pittsburgh	−6	−4	−31	−20	−18	−9	−19	−20
Altoona	−4	−3	−7	−12	−6	−11	−10	−10
New York	−11	−4	−28	−13	−6	−8	−20	−18
Phoenix	−4	−3	−4	−2	−4	−3	−3	−6
State College	N	−2	−3	N	−2	−3	N	N

[a] Evidence of mechanical damage.
[b] No evidence of corrosion observed.

exposure further enhances the significance of the indicated behavior. However, in most cases, the changes are too small to be of significance, and in certain cases there are obvious inconsistencies which cannot be explained at present.

The subcommittee does not feel that a more specific discussion of the data is justified at this time, believing it best to await the attaining of data from the more extended exposure periods.

Respectfully submitted on behalf of the subcommittee,

C. L. HIPPENSTEEL,
Chairman.

REPORT OF COMMITTEE B-4

ON

ELECTRICAL-HEATING, ELECTRICAL-RESISTANCE AN ELECTRIC-FURNACE ALLOYS

Two meetings of Committee B-4 were held in New York City
October 17 and 18, 1933, and February 19 and 20, 1934, in additi
to the meeting held during the annual meeting of the Society.

The present membership of the committee is 28, of which
are classified as producers, 12 as consumers and 3 as general interest

Recommendations Affecting Standards

I. Proposed Tentative Standard.—The committee recommen
that the proposed Tentative Method of Test for Linear Expansi
of Metals, appended hereto,[1] be accepted for publication as tentativ
This method is intended for determining the expansion of oxidatio
resistant alloys at temperatures up to 1000 C., and employs a quar
tube dilatometer in an electric tube furnace. The construction
a suitable furnace is described. An alternative method has bee
included for use in cases where it is desired to obtain expansion dat
at greater rates of temperature change than are possible with th
standard procedure. The general procedure described has been use
for years in several laboratories with good results.

II. Proposed Revision of Tentative Standard.—The committe
recommends that the proposed chemical methods for the determina
tion of aluminum and titanium, appended hereto,[2] be included i
the Tentative Methods of Chemical Analysis of Metallic Materia
for Electrical Heating (B 71 – 33 T),[3] and with the addition of thes
procedures the methods be continued as tentative.

A sample of alloy having a nominal composition of 80 per cen
nickel and 20 per cent chromium was analyzed for aluminum by th
proposed method in two laboratories. Laboratory No. 1 reporte

---

[1] See p. 733 .—Ed.

[2] These procedures have been incorporated in the revised methods which appear on p. 710.—E

[3] *Proceedings,* Am. Soc. Testing Mats., Vol. 33, Part I, p. 648 (1933); also 1933 Book of A.S.T.
Tentative Standards, p. 269.

the aluminum content as 0.54 and 0.56 per cent, and laboratory No. 2 reported 0.55 and 0.55 per cent aluminum.

A 1-g. sample of an 18 per cent chromium, 8 per cent nickel alloy containing titanium was added to a 1-g. sample of an 80 per cent nickel, 20 per cent chromium alloy and this sample was analyzed by the proposed method in two laboratories. Both laboratories reported the titanium content as 0.21 per cent.

III. Adoption of Tentative Standards as Standard.—The committee recommends that the following three tentative standards be adopted as standard, without revision:

Tentative Specifications for Drawn or Rolled Alloy, 80 per cent Nickel, 20 per cent Chromium, for Electrical Heating Elements (B 82 – 31 T)[1]

Tentative Specifications for Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, and Balance Iron, for Electrical Heating Elements (B 83 – 31 T)[1]

Tentative Method of Test for Determining the Temperature-Resistance Constants of Resistance Alloys (B 84 – 31 T)[1]

The recommendations in this report have been submitted to letter ballot of the committee, which consists of 28 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Method of Test for Linear Expansion of Metals	19	0	2
II. PROPOSED REVISION OF TENTATIVE STANDARD			
Methods of Chemical Analysis of Metallic Materials for Electrical Heating (B 71 – 33 T)	20	0	1
III. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications for Drawn or Rolled Alloy, 80 per cent Nickel, 20 per cent Chromium, for Electrical Heating Elements (B 82 – 31 T)	20	0	1
Specifications for Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, and Balance Iron, for Electrical Heating Elements (B 83 – 31 T)	19	0	2
Method of Test for Determining the Temperature-Resistance Constants of Resistance Alloys (B 84 – 31 T)	20	0	1

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Life Tests (J. W. Harsch, chairman).—The question of making the accelerated life test at higher temperatures than those now specified has been given consideration, especially for materials having long life, in order to expedite the test. Arrangements have been made for comparative tests in several laboratories on a sample of 80 per cent nickel, 20 per cent chromium wire at temperatures of 1950, 2000 and 2050 F. (1065, 1095 and 1120 C.).

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 708, 712, 732 (1931); also 1933 Book of A.S.T.M. Tentative Standards, pp. 261, 265, 286.

The life of a heater wire as determined by the accelerated li test is largely affected by the repeated heating and cooling due t interruptions in the current. It, therefore, does not correctly represent the life of the wire in continuous service or with few interruption The development of a life test for these conditions has been discusse but has not been attempted as the test would require a long tim unless very high temperatures were used, and in this case the accurac of the test would be in question.

Subcommittee II on Electrical Tests (H. L. Curtis, chairman).– A method of test for temperature coefficient of sheet manganin i being developed. A sample is being tested in three laboratories t determine the procedure to be followed in preparation of the specime for test.

The question of preparing standard methods of testing thermocouple materials has been discussed with the Scientific Apparatu Makers of America and the National Bureau of Standards. A questionnaire sent out to the industry showed a difference of opinio regarding the undertaking of this work. Probably the most complet information now available on the subject is given in Bureau of Standards *Technological Paper No. 170*, but it is not in the most usabl form. The committee adopted a resolution suggesting that th Bureau provide a simplified revision of this paper. A book on thi subject is now in preparation with the possibility of a paper fo presentation before the Society next year.

Subcommittee III on Chemical Analysis (T. R. Cunninghan chairman).—Methods of chemical analysis for determining aluminun and titanium in nickel-chromium and nickel-chromium-iron alloys appended hereto,[1] have been prepared and are being submitted fo addition to the Tentative Methods of Chemical Analysis of Metalli Materials for Electrical Heating (B 71 – 33 T).

Subcommittee IV on Mechanical Tests (P. H. Brace, chairman).– Arrangements have been made to apply the bend test developed b Mr. Howard Scott[2] to samples of 18 per cent chromium, 8 per cen nickel steel submitted by the Joint Research Committee of th A.S.M.E. and A.S.T.M. on Effect of Temperature on the Propertie of Metals.

A pendulum type testing machine for determining the temper o heater wires and electrical-resistance wires developed by the Bel Telephone Laboratories is being studied by the subcommittee as i appears to have a wide application.

---

[1] These procedures have been incorporated in the revised methods which appear on p. 710.—E

[2] Howard Scott, "High-Temperature Characteristics of Metals Revealed by Bending," *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part II, p. 129 (1931).

Subcommittee V on Wrought and Cast Alloys for High-Temperature Use (C. L. Clark, chairman).—This subcommittee has been cooperating closely with the Joint Research Committee on Effect of Temperature on the Properties of Metals. Mr. F. E. Bash has been appointed a member of the Joint Research Committee to represent Committee B-4.

For high-temperature tension tests above 1200 F. (650 C.) the subcommittee considers that a longer test specimen is desirable than that specified in the Tentative Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials (E 21 – 33 T)[1] so that the threads will be outside of the testing temperature range. A pattern for the proposed specimen has been made. Specimens of 18 per cent chromium, 8 per cent nickel alloy and 15 per cent chromium, 35 per cent nickel alloy have been made and are being examined with X-ray before testing to determine whether sound castings have been obtained.

In order to determine the tendency of alloys to warp, a tubular specimen with eccentric bore is being considered to be quenched vertically. Specimens of several alloys are being secured for test.

A proposed Tentative Method of Test for Linear Expansion of Metals has been prepared and is being submitted for publication as tentative as appended hereto.[2]

Subcommittee VII on Thermostatic Metals (P. H. Brace, chairman).—Section A on Nomenclature and Definitions has devoted considerable time to a study of suitable terms to designate the basic properties of thermostatic metals, and also to secure a new word to serve as a standard name for this class of products to replace the various names now in use. A list of terms and their definitions is being prepared.

Section B on Methods of Testing is making a further study of the testing apparatus for determining the bending properties of thermostatic metals under load and temperature.

The program has been discussed with representatives of the Thermostatic Bi-metals Manufacturers Association to arrange for cooperation and avoid duplication of work. Arrangements have been made for the Association to participate in the work of the committee through membership on Committee B-4 and Subcommittee VII.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

---

[1] See p. 1214.—ED.

[2] See p. 733.—ED.

This report has been submitted to letter ballot of the committe which consists of 28 members; 21 members returned their ballot all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

DEAN HARVEY,
Chairman.

F. E. BASH,
Secretary.

EDITORIAL NOTE

The proposed Tentative Method of Test for Linear Expansion of Meta was accepted for publication as tentative and appears on page 733.

The revision of the Tentative Methods of Chemical Analysis of Metall Materials for Electrical Heating, covering the addition of chemical methods f the determination of aluminum and titanium, was accepted. The methods i their revised form appear on page 710.

The Tentative Specifications for Drawn or Rolled Alloy, 80 per cent Nicke 20 per cent Chromium, for Electrical Heating Elements; Specifications f Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, and Balanc Iron, for Electrical Heating Elements; and Method of Test for Determinin the Temperature-Resistance Constants of Resistance Alloys were approved a the annual meeting and subsequently adopted as standard by letter ballot the Society on September 1, 1934, and appear in the 1934 Supplement to Boo of A.S.T.M. Standards, pages 75 to 88, inclusive.

REPORT OF COMMITTEE B-5

ON

COPPER AND COPPER ALLOYS, CAST AND WROUGHT

Committee B-5 on Copper and Copper Alloys, Cast and Wrought, at a meeting held in Atlantic City, N. J., on June 28, 1934, during the annual meeting of the Society, gave consideration to several new specifications for copper-silicon alloys, prepared by Subcommittee I on Wrought Metals and Alloys (D. K. Crampton, chairman) and to tentative revisions of several existing standards proposed by Subcommittee II on Cast Metals and Alloys (G. H. Clamer, acting chairman). At this meeting the recommendations recorded below were approved for reference to letter ballot of the committee to be referred subsequent to the annual meeting to the Society for acceptance through Committee E-10 on Standards:

I. *Proposed Tentative Standards.*—The following three new specifications were recommended for publication as tentative:

Tentative Specifications for Copper-Silicon Alloy Plates and Sheets (B 96 – 34 T)[1]
Tentative Specifications for Sheet Copper-Silicon Alloy (B 97 – 34 T)[1]
Tentative Specifications for Copper-Silicon Alloy Rods, Bars and Shapes (B 98 – 34 T)[1]

II. *Proposed Revisions of Standards.*—Revisions of the following three standards were recommended for publication as tentative:

Standard Specifications for Sand Castings of the Alloy: Copper 88 per cent; Tin 8 per cent; Zinc 4 per cent (B 60 – 28)[2]
Standard Specifications for Steam or Valve Bronze Sand Castings (B 61 – 28)[2]
Standard Specifications for Composition Brass or Ounce Metal Sand Castings (B 62 – 28)[2]

III. *Withdrawal of Standard.*—In view of the fact that the alloy covered by the Standard Specifications for the Alloy: Copper 88 per cent; Tin 10 per cent; Zinc 2 per cent (B 10 – 18)[3] is included in the Standard Specifications B 60 – 28, it is accordingly proposed that Specifications B 10 be discontinued.

---

[1] See pp. 692, 699 and 695, respectively.—Ed.

[2] 1933 Book of A.S.T.M. Standards, Part I, pp. 589, 608, and 612.

[3] *Ibid.*, p. 586.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

Respectfully submitted on behalf of the committee,

C. H. MATHEWSON,
Chairman.

D. K. CRAMPTON,
Secretary.

EDITORIAL NOTE

Recommendations to Committee E-10 on Standards.—The following recommendations were accepted by Committee E-10 on Standards on August 22, 1934: Proposed Tentative Specifications for Copper-Silicon Alloy Plates and Sheets; for Sheet Copper-Silicon Alloy; and for Copper-Silicon Alloy Rods, Bars and Shapes were accepted for publication as tentative and appear on pages 692, 699 and 695, respectively. Tentative revisions of the Standard Specifications for Sand Castings of the Alloy: Copper 88 per cent, Tin 8 per cent, Zinc 4 per cent; for Steam or Valve Bronze Sand Castings; and for Composition Brass or Ounce Metal Sand Castings were accepted and appear on pages 1259 and 1260. The withdrawal of the Standard Specifications for the Alloy: Copper 88 per cent; Tin 10 per cent; Zinc 2 per cent was approved.

REPORT OF COMMITTEE B-6
ON
DIE-CAST METALS AND ALLOYS

Committee B-6 on Die-Cast Metals and Alloys has held two meetings during the year, at Chicago, in June, 1933, and at New York City in February, 1934, with an attendance of about 35 at each meeting. In addition, several of the subcommittees have held meetings at various times during the year. Since the last annual report the committee has elected five new members, and three company members have designated new representatives on the committee. The committee regrets the loss through death of one of its members, Mr. A. H. Tallman of Hamilton, Ontario, Canada.

At present the committee has 64 members serving either as individuals or as company representatives. In addition to the representation of the Society of Automotive Engineers on the committee, the Vice-Chairman, Mr. D. L. Colwell, has been designated by both the Non-Ferrous Metals Division of the S.A.E. and by Committee B-6 as a liaison representative between the two groups.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Standard.—The committee recommends that the proposed Tentative Specifications for Magnesium-Base Alloy Die Castings, as appended hereto,[1] be accepted for publication as tentative. This recommendation has been submitted to letter ballot of the committee which consists of 53 members; 42 members returned their ballots, of whom 31 have voted affirmatively, none negatively and 11 members marked their ballots not voting.

II. Specifications Continued as Tentative.—The committee recommends that the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 33 T) and the Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 – 33 T)[2] be continued as tentative without revision, with the likelihood that revisions will be made during the coming year as noted under the respective subcommittee reports.

---

[1] See p. 703.—Ed.

[2] A revision of the Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 – 33 T) was presented to Committee E-10 on Standards subsequent to the annual meeting, see Editorial Note, p. 254.—Ed.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Aluminum-Base Die-Casting Alloys (E. E. Thum, chairman).—On the basis of experimental work in the Aluminum Company Research Laboratories, the subcommittee voted to undertake the study of alloys similar to the 5 and 12-per-cent silicon aluminum alloys, Nos. IV and V, respectively, of the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 33 T), but of considerably higher purity and with narrower composition ranges. For example, the total of all impurities other than iron in the high purity alloy No. V would be about 0.7 per cent, maximum, as contrasted with 2.35 per cent, maximum, in the present alloy. The evidence available indicated that such high-purity alloys could be expected to show better corrosion resistance than the present commercial alloys; copper, zinc, and tin appear to accelerate corrosion in these alloys while iron, manganese, nickel and magnesium do not appear to be detrimental within the specified limits.

The subcommittee is conducting a questionnaire among its members designed to determine whether there exists sufficient demand to justify the preparation of specifications covering ingots intended for the manufacture of die castings. The initial replies from two large consumers and one producer indicate that at least 90 per cent of the die-casters' requirements are purchased in the form of compounded aluminum ingots and that A.S.T.M. specifications would supply a very definite need. If this demand is substantiated by further replies, it is contemplated that additional ingot alloys will be added to and appropriate changes made in the title of the Tentative Specifications for Aluminum-Base Sand-Casting Alloys in Ingot Form (B 58 – 33 T) through cooperative action of Committee B-6 and Committee B-7 on Light Metals and Alloys, Cast and Wrought.

Subcommittee II on Zinc-Base Die-Casting Alloys (W. H. Graves, chairman).—On the basis of experimental work in the New Jersey Zinc Co. Laboratories it would appear that the aluminum content of alloy No. XXIII in the Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 – 33 T) should be reduced from 4.50 to 4.30 per cent maximum. This investigation is described in a paper by E. A. Anderson and G. L. Werley, entitled "The Effect of Variations in Aluminum Content on the Strength and Permanence of the A.S.T.M. No. XXIII Zinc Die-Casting Alloy," which appears as an Appendix to this report. As this valuable contribution to the work of the subcommittee did not become available in time for committee action this year, it is expected that the desirability of making the appropriate change in Specifications B 86 – 33 T will be determined during the coming year.

The necessity for further revision of the Special High-Grade Slab Zinc in the Standard Specifications for Slab Zinc (Spelter) (B 6 – 33), particularly with respect to the maximum lead content, has been called to the attention of Subcommittee I on Pure Metals in Ingot Form of Committee B-2 on Non-Ferrous Metals and Alloys. The maximum lead content for the Special High-Grade Slab Zinc in Specifications B 6 – 33 was recently set to correspond with the maximum for alloy No. XXI in the Tentative Specifications B 86 – 33 T. However, with the addition to Specifications B 86 – 33 T of Alloy No. XXIII having a lower lead content and the revision of Alloy No. XXI to correspond, further restriction of the impurity limits for Special High-Grade Zinc in Specifications B 6 – 33 becomes necessary and Committee B-2 has agreed to consider the matter during the coming year.

Subcommittee III on Tin- and Lead-Base Die-Casting Alloys (G. O. Hiers, chairman).—This subcommittee has agreed to report proposed tentative specifications covering these low-melting-point alloys at the June, 1934, annual meeting which should be ready for publication a year hence.

Subcommittee IV on Physical Tests of Die Castings (R. L. Templin, chairman).—A type of rotating-beam fatigue test specimen, suitable for die-casting alloys, has been designed and tried out by two laboratories with very satisfactory results. Comparative fatigue tests using flat cantilever specimens are also being undertaken by one of the cooperating laboratories.

After consideration of the desirability of introducing a plain transverse bend test for die-cast specimens, the subcommittee has concluded that this form of test affords no information beyond that obtainable with more precision from tension and elongation measurements on the standard tension specimen shown in the Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 – 33 T).

Subcommittee V on Exposure and Corrosion Tests (W. M. Peirce, chairman).—This subcommittee has been the most active of any during the past year. It has made a photographic survey of the committee specimens on the outdoor exposure racks and also formulated plans for the physical testing of the five-year exposed specimens to be brought back from the field and distributed to the cooperating testing laboratories in July, 1934. The report of the subcommittee on the inspection of the zinc die-cast specimens exposed at the six "outdoor" locations is appended to this report.

Subcommittee VII on Magnesium-Base Die-Casting Alloys (J. A. Gann, chairman).—This subcommittee is recommending for publication as appended hereto[1] the proposed Tentative Specifications for Magnesium-Base Alloy Die Castings, with explanatory notes.

In view of the interest which has been expressed in magnesium-base alloy die castings, the committee has deemed it advisable to prepare these specifications which incorporate the composition which is now considered most desirable for magnesium-base die castings, so that prospective users may have the benefit of the information. It is anticipated that revisions will be made in the specifications when more members of the committee have been able to experiment with the use of the recommended alloy and other magnesium-base alloys.

The election of officers for the ensuing term of two years resulted in the selection of J. R. Townsend, chairman; W. H. Graves, vice-chairman; and P. V. Faragher, secretary.

This report has been submitted to letter ballot of the committee which consists of 53 members; 42 members returned their ballots, of whom 41 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

H. A. ANDERSON,
Chairman.

P. V. FARAGHER,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Magnesium-Base Alloy Die Castings were accepted for publication as tentative and appear on page 703.

Recommendation to Committee E-10 on Standards.—Subsequent to the annual meeting Committee B-6 on Die-Cast Metals and Alloys presented to the Society through Committee E-10 on Standards a revision of the Tentative Specifications for Zinc-Base Alloy Die Castings which was accepted on August 22, 1934. The specifications in their revised form appear on page 706.

---

[1] See p. 703.—ED.

REPORT OF SUBCOMMITTEE V ON EXPOSURE AND CORROSION TESTS

With the approval of Committee B-6, the chairman of Subcommittee V has inspected the die-cast specimens which have been exposed for somewhat over four years at Key West, Fla., Sandy Hook, N. J., New York, N. Y., Altoona, Pa., State College, Pa., and Rochester, N. Y. All of the specimens on one set of racks at each location have been photographed and the zinc impact specimens which were measured before exposure have been remeasured and the change in dimensions calculated.

One set of racks should, according to the original plan, have been returned for testing in June, 1932. It was found impossible to secure the necessary cooperation of testing laboratories to carry out the physical tests at that time and, by recommendation of the subcommittee and action of Committee B-6, the three-year exposure period for these racks was extended to five years, and the five-year exposure period for the remaining set of racks was extended to ten years.

The opinion has been held by some engineers and metallurgists that some of these alloys would suffer severely by corrosion when exposed outdoors. This opinion was not universal and the interest in the condition of the specimens after four years of exposure engendered by this difference of opinion made a visual inspection appear worth while.

A photographic apparatus was constructed employing a $2\frac{1}{4}$ by $4\frac{1}{4}$-in. camera with a double extension bellows rigidly attached to the same base as a rack holding a group of five tension specimens. A white background and a white reflector were attached to the same base. Practically all of the photographs were made with sunlight, using a diffusing screen between the sun and the specimens. It was necessary to take a few photographs during a cloudy period using the direct light from the sky. This did not seem to affect the detail and contrast obtained.

The specimens were carefully removed from the racks in groups of five check specimens, each group representing one producer and one alloy. So far as possible, the three left-hand specimens in each photograph were turned with the top side of the specimens toward the camera and the right-hand specimens with the bottom side toward the camera. In many cases, however, the difference in appearance of the top and bottom side was not sufficiently pronounced to insure obtaining this arrangement.

The Sandy Hook racks were inspected on July 13, 1933, the Key West racks on July 18, 1933, the New York racks on August 3, 1933, the State College racks on August 8, 1933, the Altoona racks on August 8, 1933, and the Rochester racks on August 16, 1933. A few of the Key West specimens had to be rephotographed due to the use of a defective film pack during the original inspection. This was done on September 19, 1933, and was made possible through the courtesy of Mr. L. M. Pierce of the U. S. Naval Station, who had assisted during the original inspection and who arranged to have the retakes made with the apparatus which was shipped to him.

The report of this inspection is primarily a photographic record. It is the chairman's belief that the photographs give an essentially true picture of the surface appearance of the specimens in every case and comments have been made only on such points as were so outstanding that no possible difference of opinion could exist. Obviously, no deductions concerning changes in tensile strength or other physical properties can be drawn from these superficial observations. The actual physical testing which is scheduled for June, 1934, will be required to give that side of the picture.

Two copies of this report have been made, containing a complete set of the photographs enlarged to normal size. One of these copies has been placed with the records of Committee B-6 and the other copy placed in the files of Subcommittee V. Actually, as would be expected, a great many of the sets of specimens were identical in appearance and it was felt that the loss of detail in the printed reproductions would be so great that the expense of printing the photographs in the *Proceedings* was not justified. The accompanying photograph, Fig. 1, "Sandy Hook—21-S" illustrates the appearance of one set of bars conforming to alloy No. XXI of the Tentative Specifications B 86 - 31 T, after four years outdoor exposure to the sea-coast atmosphere at Fort Hancock, Sandy Hook, N. J.

The dimensional change of the zinc impact specimens has been calculated and is given in Table I. The average for each group of five specimens is given. For the convenience of those studying the report, Table II showing the composition of each alloy, is also given.

It will be noted that only alloys Nos. 15, 16, and 21 were measured at Sandy Hook. Due to lack of time, all of the alloys could not be measured and these were selected as probably being of the most importance. It is fairly evident from data on the other exposures

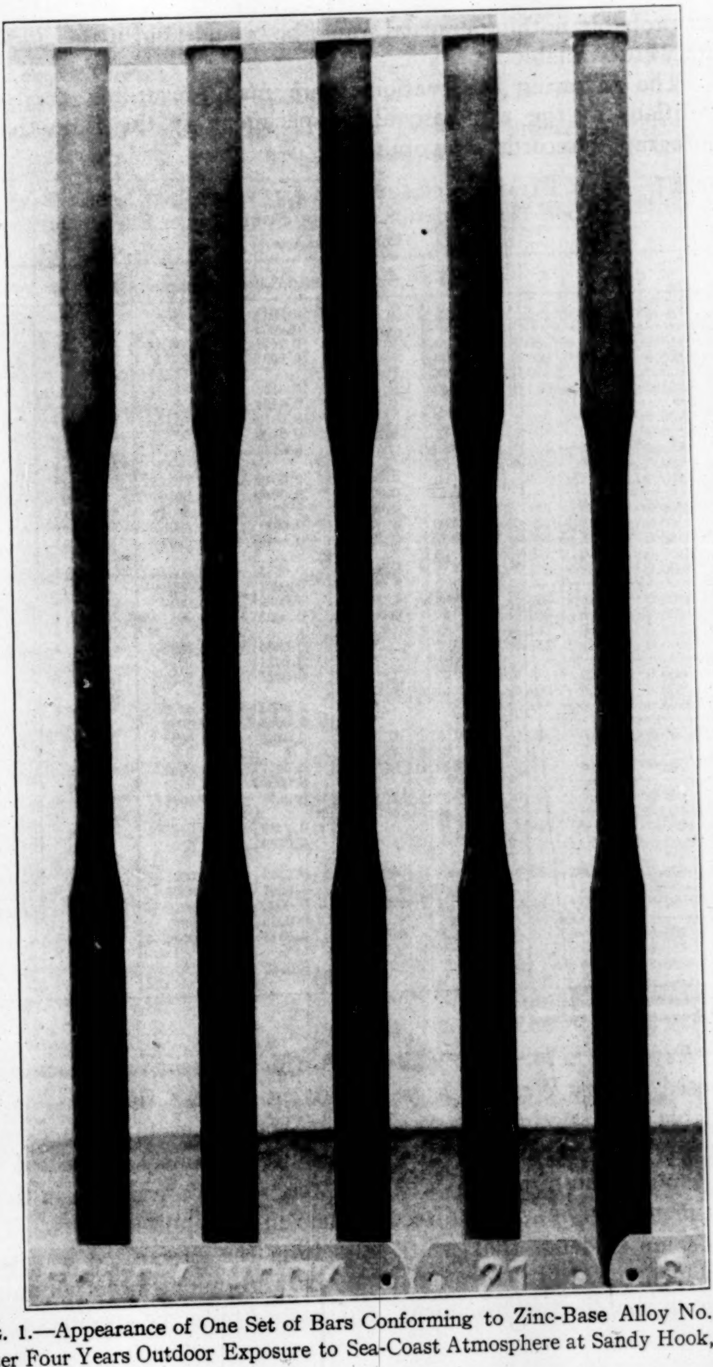


FIG. 1.—Appearance of One Set of Bars Conforming to Zinc-Base Alloy No. XXI After Four Years Outdoor Exposure to Sea-Coast Atmosphere at Sandy Hook, N. J.

that probably nothing unusual would be brought out if this additional data were available.

The following observations were made regarding the surface conditions of the zinc-base alloy specimens at the time that the photographic records were obtained.

TABLE I.—TOTAL EXPANSION OF 6-IN. ZINC ALLOY DIE CAST IMPACT BARS AT SIX OUTDOOR TEST LOCATIONS AFTER FOUR YEARS EXPOSURE.

	Exposure Locations					
Code	Key West	Sandy Hook	State College	Rochester	New York	Altoona
13-C	0.0144	[a]	0.0014	[b]	0.0020	0.0020
13-D	0.0117	[a]	0.0018	[b]	0.0022	0.0027
13-R	0.0132	[a]	0.0021	[b]	0.0027	0.0025
13-T	0.0155	[a]	0.0025	[b]	0.0030	0.0043
14-C	0.0336	[a]	0.0153	[b]	0.0187	0.0184
14-D	0.0819	[a]	0.0254	[b]	0.0276	0.0263
14-R	0.1657	[a]	0.0373	[b]	0.0390	0.0398
14-S	0.0451	[a]	0.0163	[b]	0.0186	0.0204
14-T	0.0555	[a]	0.0235	[b]	0.0254	0.0241
15-C	0.0127	0.0025	0.0018	0.0032	0.0032	0.0042
15-D	0.0163	0.0060	0.0040	0.0039	0.0060	0.0053
15-R	0.0092	0.0010	0.0004	0.0001	0.0021	0.0024
15-S	0.0136	0.0044	0.0031	0.0026	0.0047	0.0049
15-Z	0.0206	0.0065	0.0047	0.0041	0.0079	0.0066
16-C	0.0153	0.0048	0.0035	0.0032	0.0053	0.0058
16-D	0.0169	0.0046	0.0031	0.0034	0.0059	0.0056
16-S	0.0144	0.0056	0.0032	0.0024	0.0058	0.0044
16-Z	0.0130	0.0031	0.0022	0.0021	0.0047	0.0039
17-D	0.0128	[a]	0.0030	0.0022	0.0047	0.0035
17-S	0.0132	[a]	0.0031	0.0021	0.0052	0.0038
17-T	0.0180	[a]	0.0037	0.0023	0.0056	0.0041
18-C	0.0183	[a]	0.0052	0.0070	0.0055	0.0056
18-S	0.0261	[a]	0.0063	0.0086	0.0133	0.0101
18-T	0.0260	[a]	0.0103	0.0088	0.0099	0.0095
19-D	0.0089	[a]	0.0017	0.0003	0.0023	0.0024
19-R	0.0057	[a]	0.0000	−0.0013	0.0001	0.0006
19-Z	0.0068	[a]	0.0016	0.0014	0.0021	0.0023
20-C	0.0678	[a]	0.0135	0.0180	0.0194	0.0196
20-D	0.1439	[a]	0.0309	0.0294	0.0365	0.0353
21-D	0.0105	0.0027	0.0035	0.0023	0.0031	0.0036
21-R	0.0072	0.0008	0.0001	−0.0005	0.0008	0.0005
21-S	0.0046	−0.0002	0.0003	−0.0010	−0.0004	0.0012
21-T	0.0102	0.0028	0.0036	0.0023	0.0034	0.0040
21-Z	0.0088	0.0015	0.0015	0.0006	0.0012	0.0030
22-C	0.0288	[a]	0.0142	[b]	0.0135	0.0164

[a] Specimens were not measured.
[b] Specimens not in exposure rack.

Key West, Fla.—The white salts which appear on the specimens exposed at Key West (to a greater extent on 16-Z than on 19-Z) are variable from specimen to specimen in the same group of check specimens. Their extent and distribution are obviously connected with the wind or sun direction since they were more pronounced in tiers of specimens sloping in one direction than in the opposite tiers. There was some evidence that white salts from the galvanized iron racks, on which the white corrosion products were much more voluminous than on the die-cast specimens, had washed onto the specimens. All of the specimens of alloy No. 13 showed some roughening and evidence of more corrosion.

TABLE II.—ANALYSIS OF ZINC-BASE ALLOY DIE-CAST SPECIMENS EXPOSED AT OUTDOOR LOCATIONS.

Code	Nominal Compositions Desired						Results of Chemical Analyses[a]						
	Aluminum, per cent	Copper, per cent	Zinc Grade	Magnesium, per cent	Tin, per cent	Nickel, per cent	Aluminum, per cent	Copper, per cent	Magnesium, per cent	Lead, per cent	Cadmium, per cent	Tin, per cent	Nickel, per cent
13-C	0.25	5	H.G.[c]	...	..	....	0.24	4.6	none	0.067	0.035	0.031	[b]
13-D	0.25	5	H.G.[c]	...	..	....	0.35	4.50	none	0.044	0.045	0.028	[b]
13-R	0.25	5	H.G.[c]	...	..	....	0.21	4.60	none	0.050	0.012	0.072	[b]
13-T	0.25	5	H.G.[c]	...	..	....	0.25	5.25	none	0.050	<0.002	0.002	[b]
14-C	4	3	H.G.[c]	...	..	....	3.4	3.2	none	0.040	0.02	0.0007	[b]
14-D	4	3	H.G.[c]	...	..	....	3.90	3.15	none	0.045	0.04	0.027	[b]
14-R	4	3	H.G.[c]	...	..	....	3.70	3.00	none	0.045	0.007	0.038	[b]
14-S	4	3	H.G.[c]	...	..	....	4.30	2.85	none	0.046	0.03	0.002	[b]
14-T	4	3	H.G.[c]	...	..	....	3.8	3.0	0.0007	0.043	<0.002	0.001	[b]
15-C	4	3	H.G.[c]	0.1	..	....	3.5	3.1	0.11	0.038	0.02	0.0005	[b]
15-D	4	3	H.G.[c]	0.1	..	....	4.05	2.95	0.09	0.028	0.038	0.009	[b]
15-R	4	3	H.G.[c]	0.1	..	....	3.75	3.10	0.07	0.053	0.011	0.006	[b]
15-S	4	3	H.G.[c]	0.1	..	....	3.95	2.80	0.13	0.041	0.025	0.0015	[b]
15-Z	4	3	H.G.[c]	0.1	..	....	3.85	3.1	0.1	0.059	0.025	0.0003	[b]
16-C	4	3	99.94	0.1	..	....	4.35	3.2	0.15	0.050	<0.002	0.0008	[b]
16-D	4	3	99.94	0.1	..	....	4.00	3.05	0.09	0.050	0.003	0.003	[b]
16-S	4	3	99.94	0.1	..	....	4.20	2.85	0.13	0.047	0.004	0.017	[b]
16-Z	4	3	99.94	0.1	..	....	3.8	3.2	0.13	0.042	0.002	0.0005	[b]
17-D	3	3	H.G.[c]	0.3	..	....	3.15	2.85	0.33	0.031	0.036	0.001	[b]
17-S	3	3	H.G.[c]	0.3	..	....	3.30	2.55	0.28	0.052	0.015	0.003	[b]
17-T	3	3	H.G.[c]	0.3	..	....	3.0	3.0	0.33	0.040	0.002	0.0008	[b]
18-C	0.5	3	P.W.[d]	...	6	....	0.23	2.7	none	0.70	0.35	6.75	[b]
18-S	0.5	3	P.W.[d]	...	6	....	0.85	3.15	0.0025	1.1	0.45	5.0	[b]
18-T	0.5	3	P.W.[d]	...	6	....	0.30	2.45	0.012	0.50	0.2	6.15	[b]
19-D	4	2	99.94	0.1	..	0.02	4.15	2.30	0.10	0.044	0.002	0.003	0.022
19-R	4	2	99.94	0.1	..	0.02	3.85	1.95	0.09	0.044	0.011	0.005	0.013
19-Z	4	2	99.94	0.1	..	0.02	4.00	2.1	0.12	0.042	0.002	0.0004	0.03
20-C	4	3	Intermediate[e]	...	..	....	4.05	2.90	0.001	0.55	0.3	0.009	[b]
20-D	4	3	Intermediate[e]	...	..	....	3.80	3.15	none	0.25	0.025	0.12	[b]
21-D	4	3	S.H.G.[f]	0.1	..	....	4.00	3.00	0.13	0.0034	0.004	0.003	[b]
21-R	4	3	S.H.G.[f]	0.1	..	....	3.75	3.00	0.08	0.0023	0.0035	0.005	[b]
21-S	4	3	S.H.G.[f]	0.1	..	....	4.05	2.95	0.10	0.0043	0.002	<0.0025	[b]
21-T	4	3	S.H.G.[f]	0.1	..	....	4.00	2.80	0.14	0.0027	0.002	0.0005	[b]
21-Z	4	3	S.H.G.[f]	0.1	..	....	4.05	2.95	0.12	0.0018	0.0013	<0.0025	[b]
22-C	0.5	3	H.G.[c]	...	6	....	0.38	3.3	0.005	0.053	0.022	6.20	[b]

[a] Chemical analyses were made by The New Jersey Zinc Co.

[b] Not analyzed.

[c] High Grade Zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (B 6 – 33), see 1933 Book of A.S.T.M. Standards, Part I, p. 858.

[d] Prime Western Zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (B 6 – 33), see 1933 Book of A.S.T.M. Standards, Part I, p. 858.

[e] Intermediate Zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (B 6 – 33), see 1933 Book of A.S.T.M. Standards, Part I, p. 858.

[f] Special High Grade Zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (B 6 – 33), see 1933 Book of A.S.T.M. Standards, Part I, p. 858.

Sandy Hook, N. J.—The zinc specimens at Sandy Hook, with the exception of the alloy No. 13 specimens and the alloy No. 20-C specimens, have a smooth gray appearance. The alloy No. 13

specimens are speckled with white salts. The alloy No. 20-C specimens show nodules apparently originating from small blisters.

New York City.—All of the specimens on the New York City racks were very dark in color, undoubtedly from the heavy soot deposit.

Altoona, Pa.—All of the specimens at Altoona were greatly darkened by soot deposits. The top side of all the specimens has a brownish cast. The bottom side of all the specimens tends to show some white corrosion products.

State College, Pa.—All of the zinc specimens at State College were dull dark gray in appearance. Alloys Nos. 13, 17, and 20-C showed some white salts; furthermore, alloy No. 20-C was somewhat rough and nodular.

Rochester, N. Y.—The zinc specimens at Rochester were all smooth and dark in appearance, the color being due partly to the soot. The only exception was alloy No. 20 where the specimens showed small blisters.

Respectfully submitted on behalf of the subcommittee,

W. M. PEIRCE,
Chairman.

APPENDIX

THE EFFECT OF VARIATIONS IN ALUMINUM CONTENT ON THE STRENGTH AND PERMANENCE OF THE A.S.T.M. NO. XXIII ZINC DIE-CASTING ALLOY

By E. A. Anderson[1] and G. L. Werley[1]

The present A.S.T.M. Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 – 33 T)[2] cover two zinc alloys designated as Nos. XXI and XXIII with compositions as follow:

	Alloy No. XXI	Alloy No. XXIII
Copper, per cent	2.5 to 3.5	0.10, max.
Aluminum, per cent	3.5 to 4.5	3.5 to 4.5
Magnesium, per cent	0.02 to 0.10	0.03 to 0.08
Iron, max., per cent	0.100	0.100
Lead, max., per cent	0.007	0.007
Cadmium, max., per cent	0.005	0.005
Tin, max., per cent	0.005	0.005
Zinc, per cent	remainder	remainder

The present paper is concerned only with the second of these, alloy No. XXIII.

Ever since the commercial introduction of this alloy, pressure has been brought to bear by the die casters to increase the aluminum content in the interests of better castability. Although not confirmed by any actual tests brought to the authors' attention at the time this work was started, the feeling exists throughout the die-casting industry that definite improvement in casting qualities can be obtained by increases in aluminum content of as little as 0.25 per cent above the present commercial maximum of 4.3 per cent. A study of the properties other than castability affected by changing the aluminum content seemed highly desirable and has been carried out for alloy No. XXIII.

Alloys Tested:

The following alloys were prepared for test:

Alloy	Aluminum, per cent Made Up	Aluminum, per cent Analyzed
No. A-5021	4.30	4.40
No. A-5022	4.40	4.45
No. A-5023	4.50	4.50
No. A-5024	4.60	4.60
No. A-5025	4.70	4.65
No. A-5026	4.80	4.80

---

[1] Chief Investigator, and Investigator, respectively, Metal Section, Research Division, New Jersey Zinc Co., Palmerton, Pa.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 644 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 257.

The remainder of the elements present in the series fell well within the requirements of the A.S.T.M. specifications for the No. XXIII alloy. The actual analyses are compiled below:

Alloy	Magnesium, per cent	Copper,[a] per cent	Lead, per cent	Cadmium, per cent	Iron, per cent	Tin,[b] per cent
No. A-5021....	0.03	......	0.0033	0.001	0.026	......
No. A-5022....	0.037	......	0.0037	0.001	0.015	......
No. A-5023....	0.04	......	0.0035	0.001	0.012	......
No. A-5024....	0.045	......	0.0035	0.001	0.022	......
No. A-5025....	0.04	......	0.0040	0.001	0.032	......
No. A-5026....	0.041	......	0.0052	0.001	0.027	......

---

[a] None added—not analyzed.

[b] None added—not analyzed—base metal used contained about 0.0001 per cent tin.

Casting Conditions:

Die-cast test bars were prepared from each of the above alloys in a commercial plunger-type machine. The metal temperature was held at 480 C. (895 F.), the die temperature at 170 to 190 C. (340 to 375 F.), and the pressure on the metal at 1050 lb. per sq. in. It may be pointed out that the metal temperature used is somewhat higher than that recommended for commercial die casting of alloy No. XXIII. This was necessitated by the fact that the die-casting machine used was not equipped with the nozzle heater which features most commercial plunger-type machines.

Specimens:

The specimens used were the tension and impact test bars required by the Society's specifications for tests on zinc die castings. In all, 170 tension specimens and an equal number of impact bars were cast of each alloy.

Test Procedure:

Specimens were tested for tensile strength, tensile elongation, impact strength and dimensional change in the condition as cast and after accelerated aging exposures and aging in a normal room atmosphere. Ten check specimens were used in each as-cast test and five in each of the others.

The accelerated tests used were the 95 C. steam test, and a dry air anneal at this same temperature. In both cases specimens were tested after 1, 2, 3, 5, 7 and 10 days of exposure.

The aging tests were carried out in a laboratory room in which the temperature ranged from 20 to 26 C. with a relative humidity of about 50 per cent. Specimens were exposed for test periods which will ultimately extend to 6 months, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 years.

The tension tests were carried out in a standard tension testing machine at a cross-head speed (machine running idle) of 0.25 in. per minute. Impact tests were conducted in a 36.75 ft-lb. capacity Charpy-type machine.

Measurements for dimensional stability were made on the 6-in. impact bars prior to the actual impact testing. The bars were given a light machining at the ends to furnish flat parallel surfaces for measurement. All measurements were made with a 6-in. micrometer reading to 0.0001 in. A suitable jig was used to insure reproducibility in the relocation of the specimen with respect to the micrometer anvils during remeasurement after aging. For reasons which will be made apparent later, all initial measurements were made within 10 hr. of the actual time of casting.

TABLE I.—EFFECT OF VARIATION IN ALUMINUM CONTENT ON IMPACT STRENGTH OF ALLOY NO. XXIII.

Alloy	Aluminum, per cent	Impact Strength of $\frac{1}{4}$ by $\frac{1}{4}$-in. Section, ft-lb.												
		As cast	95 C. Steam Test						95 C. Dry Anneal					
			1 day	2 days	3 days	5 days	7 days	10 days	1 day	2 days	3 days	5 days	7 days	10 days
No. A-5021	4.30	31.50	29.50	>33.75	>35.50	>30.25	>34.25	>33.00	32.25	30.25	>33.25	>35.75	>34.00	>35.75
No. A-5022	4.40	27.50	31.00	28.75	30.00	28.50	>31.00	32.00	30.00	>35.50	28.75	33.50	32.00	32.50
No. A-5023	4.50	26.00	28.00	28.75	23.75	24.50	32.00	17.25	29.25	27.25	>32.75	>33.75	>33.50	>31.50
No. A-5024	4.60	20.50	7.50	5.25	7.75	13.50	16.00	6.25	12.25	7.00	8.50	10.00	7.50	4.25
No. A-5025	4.70	19.50	4.75	2.00	4.50	2.75	1.25	2.25	3.25	2.25	7.25	2.00	3.00	3.50
No. A-5026	4.80	4.50	1.50	1.50	2.00	1.25	1.50	1.25	2.25	1.75	2.50	1.25	1.50	1.25

TABLE II.—EFFECT OF VARIATION IN ALUMINUM CONTENT ON TENSILE STRENGTH OF ALLOY NO. XXIII.

Alloy	Aluminum, per cent	Tensile Strength, lb. per sq. in.												
		As cast	95 C. Steam Test						95 C. Dry Anneal					
			1 day	2 days	3 days	5 days	7 days	10 days	1 day	2 days	3 days	5 days	7 days	10 days
No. A-5021	4.30	38 400	35 700	35 500	35 200	34 500	33 400	33 200	35 900	35 500	35 000	34 300	34 100	33 600
No. A-5022	4.40	39 000	36 000	35 900	34 800	34 000	33 100	33 400	36 100	36 000	35 400	34 900	34 200	34 200
No. A-5023	4.50	38 000	35 200	35 300	35 100	33 900	33 400	33 900	35 600	35 500	35 600	34 700	34 400	34 000
No. A-5024	4.60	37 800	35 500	35 100	34 500	33 500	32 600	32 300	36 100	35 400	35 100	34 600	33 900	34 500
No. A-5025	4.70	37 200	35 000	34 900	34 500	33 500	32 600	31 600	35 600	35 500	35 200	34 900	34 200	33 900
No. A-5026	4.80	38 300	35 400	34 300	33 100	32 900	32 900	30 900	35 800	34 700	35 100	34 800	34 200	33 900

TABLE III.—EFFECT OF VARIATION IN ALUMINUM CONTENT ON TENSILE ELONGATION OF ALLOY NO. XXIII.

Alloy	Aluminum, per cent	Elongation in 2 in., per cent												
		As cast	95 C. Steam Test						95 C. Dry Anneal					
			1 day	2 days	3 days	5 days	7 days	10 days	1 day	2 days	3 days	5 days	7 days	10 days
No. A-5021	4.30	5.5	3.9	4.3	3.5	2.2	5.4	4.1	2.7	4.7	4.2	5.3	7.0	8.0
No. A-5022	4.40	4.2	4.0	2.6	2.5	1.9	3.4	2.8	5.4	4.8	5.2	3.3	5.7	7.4
No. A-5023	4.50	2.9	2.7	2.4	2.2	1.9	3.5	2.1	4.2	4.4	3.4	3.2	6.9	7.5
No. A-5024	4.60	2.0	1.6	1.6	1.7	1.5	2.0	1.4	2.7	2.3	2.8	2.6	2.2	2.8
No. A-5025	4.70	1.8	1.3	1.9	2.9	1.4	1.7	1.1	2.0	3.3	2.6	2.8	3.1	3.2
No. A-5026	4.80	1.3	1.6	1.4	1.4	0.9	1.1	0.9	1.9	1.3	2.7	2.1	1.9	1.8

TABLE IV.—EFFECT OF VARIATIONS IN ALUMINUM CONTENT ON THE DIMENSIONAL CHANGES IN 6-IN. IMPACT BARS OF ALLOY NO. XXIII.

Alloy	Aluminum, per cent	Dimensional Changes in 6-in. Impact Bars, in. in 6 in.											
		95 C. Steam Test						95 C. Dry Anneal					
		1 day	2 days	3 days	5 days	7 days	10 days	1 day	2 days	3 days	5 days	7 days	10 days
No. A-5021	4.30	−0.0042	−0.0037	−0.0035	−0.0036	−0.0029	−0.0033	−0.0039	−0.0041	−0.0040	−0.0035	−0.0036	−0.0037
No. A-5022	4.40	−0.0031	−0.0032	−0.0036	−0.0030	−0.0026	−0.0025	−0.0036	−0.0036	−0.0035	−0.0037	−0.0036	−0.0032
No. A-5023	4.50	−0.0037	−0.0031	−0.0031	−0.0029	−0.0024	−0.0025	−0.0036	−0.0038	−0.0031	−0.0036	−0.0038	−0.0038
No. A-5024	4.60	−0.0042	−0.0032	−0.0034	−0.0032	−0.0028	−0.0027	−0.0036	−0.0035	−0.0033	−0.0043	−0.0040	−0.0038
No. A-5025	4.70	−0.0032	−0.0029	−0.0030	−0.0026	−0.0028	−0.0028	−0.0037	−0.0031	−0.0033	−0.0041	−0.0042	−0.0039
No. A-5026	4.80	−0.0032	−0.0020	−0.0028	−0.0024	−0.0024	−0.0018	−0.0037	−0.0024	−0.0031	−0.0036	−0.0028	−0.0035

The test bars were given a light brushing treatment after the steam test to remove loosely adherent surface corrosion products. They were then allowed to stand for one-half hour in order to bring them to room temperature. Records were kept of the temperature existing during the initial measurements and corrections based on the thermal expansion of the alloys were applied if the temperature varied in the remeasurement. It is felt that in the hands of an experienced operator this system of measurement gives results accurate to ± 0.0002 in.

DISCUSSION

The data obtained are given in Tables I to IV, inclusive. For convenience in following the discussion, selected data have been plotted in Figs. 1 to 5, inclusive.

If the graphs are studied it is seen that each property imposes a different maximum on the aluminum content of alloy No. XXIII. These limits are briefly outlined below:

Impact Strength.—From Figs. 1 and 2 the following limits are determined:

As cast, 4.7 per cent aluminum
10-day anneal, 4.5 per cent aluminum
10-day steam, 4.4 per cent aluminum

Tensile Strength.—The tensile strength data in Table II fail to show any definite effect due to aluminum up to 4.8 per cent. The maximum imposed by this property may, therefore, be set as lying well beyond that set by impact strength.

Tensile Elongation.—The data plotted in Figs. 3 and 4 place the upper limit of aluminum as follows:

As cast, 4.4 per cent
10-day anneal, 4.5 per cent
10-day steam, 4.5 per cent

The A.S.T.M. specifications fix minimum values for the tensile elongation of alloy No. XXIII both as cast and after 10 days in steam. Aluminum contents in excess of those cited above will produce elongation values falling below these minima.

Dimensional Stability.—The data in Fig. 5 show that at or below 4.7 per cent aluminum no serious decrease in steam resistance is noted.

If the above limits are assembled the following table is obtained:

PROPERTY	TEST	PERMISSIBLE MAXIMUM ALUMINUM CONTENT, PER CENT
Impact strength	As cast	4.7
Impact strength	10-day anneal	4.5
Impact strength	10-day steam	4.4
Tensile strength	All tests	>4.8
Tensile elongation	As cast	4.4
Tensile elongation	10-day anneal	4.5
Tensile elongation	10-day steam	4.5
Dimensional stability	10-day steam	4.7

Of the properties measured, impact strength is the most important. It is particularly important, therefore, that the maximum aluminum content be set at an amount which does not endanger this property. The 10-day steam test is the most practical means of evaluating the permanence of impact strength which is the outstanding characteristic of this alloy. The results of this test must, therefore, be given careful consideration.

These considerations limit the aluminum content of alloy No. XXIII to a maximum of 4.4 per cent. In the manufacture, sampling and analysis of an alloy of this type it is not unusual to find deviations of 0.1 per cent from the true aluminum content. A positive error of this magnitude in a given lot of alloy would place it in the critical range with respect to retention of impact strength in steam. For this reason the authors are strongly in favor of placing the maximum at 4.3 per cent.

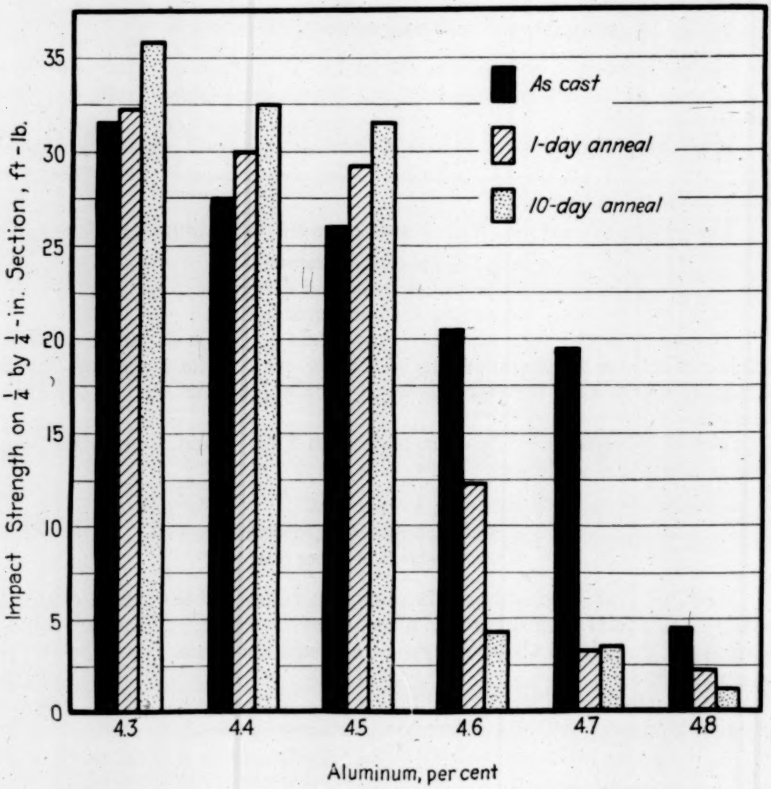


FIG. 1.—The Effect of 1 and 10-Day Dry Anneals on the Impact Strength of Alloy No. XXIII in Which the Aluminum Content Is Varied.

No mention has been made of the minimum limit. The limitation in this direction is imposed by the casting properties and not by the physical properties or permanence. Since the present work was started, opportunity was had to investigate the effect of aluminum on casting properties under representative commercial conditions. The results indicate that the optimum casting properties are reached at a minimum of 4.1 per cent of aluminum. The proposed maximum aluminum limit includes, therefore, alloys of optimum casting qualities.

It is pertinent at this point to mention that the restriction just outlined for alloy No. XXIII does not apply to alloy No. XXI. Apparently in the presence of copper, sufficient aluminum can be tolerated to make the present specification limit of 4.5 per cent aluminum acceptable in the case of the latter alloy.

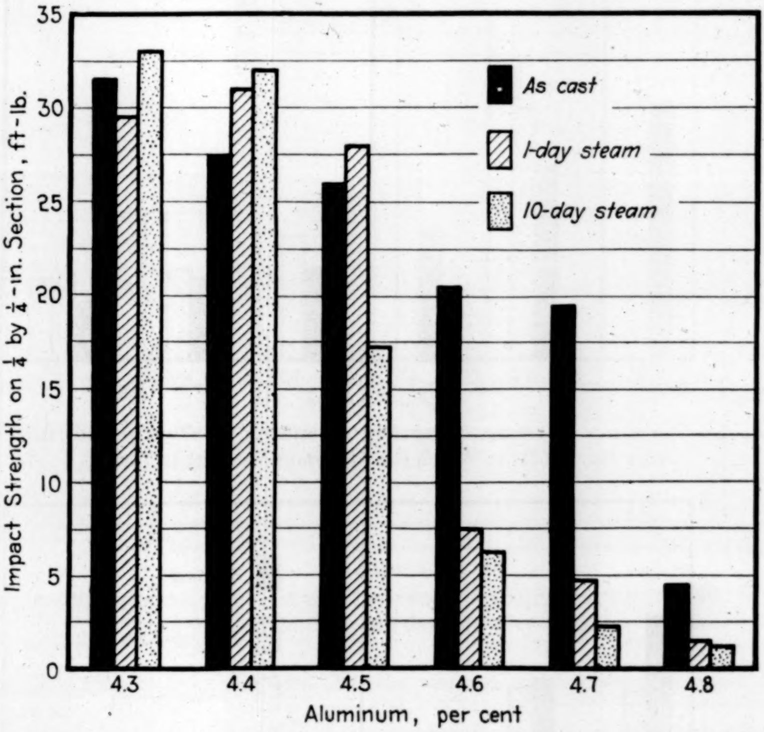


FIG. 2.—The Effect of 1 and 10-Day Steam Exposures on the Impact Strength of Alloy No. XXIII in Which the Aluminum Content Is Varied.

In addition to the major conclusions just drawn, there are a number of other considerations arising from a study of the data which warrant some discussion.

The impact strength data in Figs. 1 and 2 show the necessity for consideration of more than the data on the specimens as cast. If the latter only were available, the aluminum limit could be placed at 4.7 per cent. It is apparent, however, that the high values obtained in the 4.6 and 4.7-per cent aluminum alloys are transient since only one day at elevated temperature is required to bring these alloys to a low impact value.

The tensile elongation values reported here are somewhat lower than those obtained by other laboratories on the same alloy. In explanation of this the authors have noted that the initial value tends to run higher when the rate of cooling after removal from the die is slower than in the somewhat rapid but uniform rate established in our own practice.

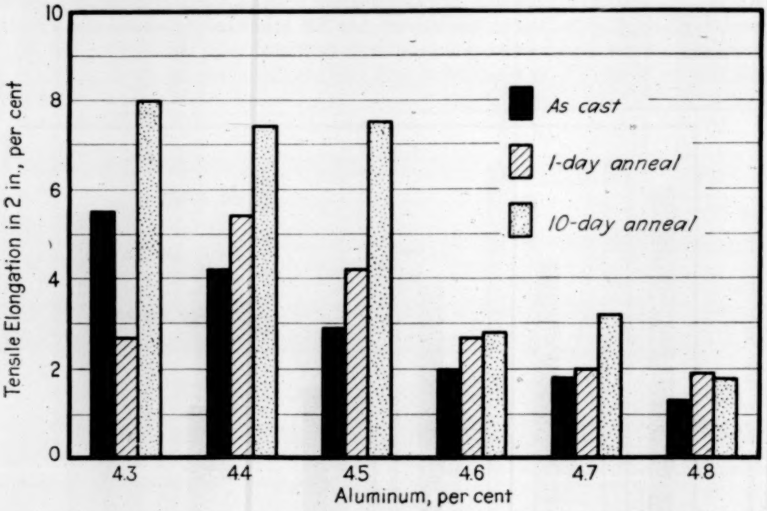


FIG. 3.—The Effect of 1 and 10-Day Dry Anneals on the Tensile Elongation of Alloy No. XXIII in Which the Aluminum Content Is Varied.

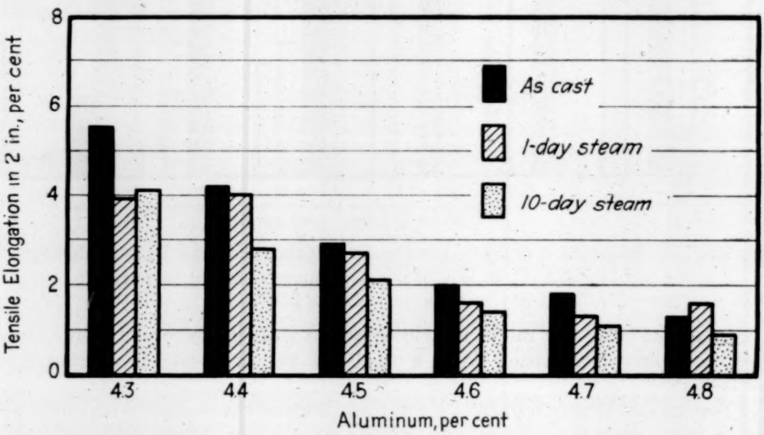


FIG. 4.—The Effect of 1 and 10-Day Steam Exposures on the Tensile Elongation of Alloy No. XXIII in Which the Aluminum Content Is Varied.

When low initial tensile elongation values are obtained in the above manner, a substantial improvement usually results from a short heat treatment at 95 C. This is evident in these data. This improvement ceases at 4.6 per cent of aluminum.

In Table IV all of the dimensional changes recorded therein are negative in sign. It is now known that all zinc die castings containing aluminum start to decrease in dimensions from the moment they leave the die. In the case of alloy No. XXIII this shrinkage continues at a fairly uniform rate for about five weeks, when the exposure is at room temperature, reaching an ultimate total shrinkage of about 0.0035 in. in 6 in.

After this change has developed to completion no further change from this source occurs. In order to measure the full extent of the shrinkage the present specimens were measured initially within 10 hr. of the actual time of casting.

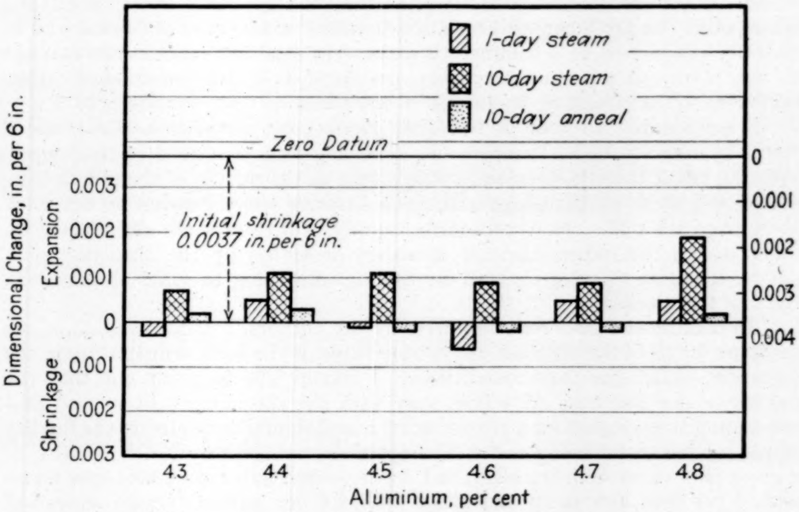


FIG. 5.—Effect of Aluminum on the Dimensional Stability of Alloy No. XXIII in the 95 C. Steam Test and the 95 C. Dry Anneal.

It is evident from the data that the reaction which requires 5 weeks to arrive at completion at room temperature will take place in one day or less at 95 C. Advantage may be taken of this acceleration to remove this dimensional change by a short anneal prior to machining where exceptionally close tolerances are to be met.

In closing, the authors would again point out that whereas the work discussed in this paper was started in an effort to find out whether the present upper aluminum limit for alloy No. XXIII could safely be raised, the results of the tests strongly indicate the desirability of a reduction in the upper limit from the present value of 4.5 per cent to the lower value of 4.3 per cent of aluminum.

DISCUSSION

Mr. Sam Tour[1].—Reference is made in this paper to the initial shrinkage in die castings during the first five weeks after manufacture. The amount of that initial shrinkage is not very considerable and there are many cases in which, in commercial production, practically no apparent initial shrinkage takes place. In producing test bars, conditions of course are not the same as in quantity production in a commercial plant. In quantity production, castings as they come out are quite hot; they are placed in a box and stacked up, so that very often a casting maintains a temperature very considerably above 95 C. for possibly an hour or two after production; in other words, it automatically receives higher temperature annealing than described in this paper, with the result that those castings which were in the middle of the pile as they cooled will show no shrinkage and those castings which happen to be taken away from the pile so as to cool fairly rapidly, will show slight shrinkage. In other words, the information on shrinkage presented by the authors should not be taken as showing that all die castings are going to suffer shrinkage in the first five weeks.

In making the tests reported upon by the authors, I understand all of the test bars for all of the different alloys were made at the same temperature in the same die, under the same conditions. I should like to point out that the fluidity of the zinc-base alloy does vary with the aluminum content and that the casting temperature for a given casting is and should be related to the fluidity of the molten metal being cast. The optimum temperature for the casting of a given part varies with the alloy, and if it is desired to compare zinc-base alloys with 4 per cent aluminum and alloys with 4.8 per cent aluminum instead of casting them all at one temperature, it might be well to determine the optimum temperature for each of those alloys and then compare the physical properties in the finished casting.

Mr. E. A. Anderson[2].—The question of shrinkage has perhaps been over emphasized. It occurs in test bars, and in carrying out research work the factor of shrinkage must not be overlooked. At the present time we are working on the problem of determining what causes the shrinkage and hope to have a paper[3] prepared for the Symposium on Die-Casting Alloys of the American Institute of Mining and Metallurgical Engineers at their fall meeting, and possibly another next February. From what we have found so far, what Mr. Tour says about the castings being piled hot and getting a higher temperature of anneal fits in very nicely.

So far as fluidity is concerned, it is mentioned in the paper that a single casting test was carried out, in which an alloy containing the low limit of aluminum content permitted in alloy No. XXIII was cast, producing an unsatisfactory casting. The aluminum content was increased and at 4.1 per cent aluminum we reached the optimum. We then increased the content to 4.8 per cent, but failed to produce any improvement in the quality of the casting. The phrase "casting quality" is open to considerable discussion. The fluidity and actual viscosity of these alloys does not change with the aluminum content in the range considered. We have set up a rather elaborate viscosimeter to investigate that point, and find no difference in the viscosity.

---

[1] Vice-President, Lucius Pitkin, Inc., New York City.

[2] Chief Investigator, Metal Section, Research Division, New Jersey Zinc Co., Palmerton, Pa.

[3] M. L. Fuller and R. L. Wilcox, "Studies of Phase Changes During Aging of Zinc-Alloy Die Castings, I.—Eutectoidal Decomposition of Beta Aluminum-Zinc Phase and Its Relation to Dimensional Changes in Die Castings," *Technical Publication No. 572-E175*, Metals Technology, Am. Inst. Mining and Metallurgical Engrs., September, 1934.

MR. C. R. INCE[1].—I should like to ask whether the authors consider the 4.3 per cent limit recommended, the optimum aluminum content from the point of view of physical properties. I notice in this paper there has been no mention made of the minimum limit. Did the authors conduct any experiments on 3.9 and 4.1 per cent for physical properties, and if so, how did they compare with the 4.3-per-cent aluminum alloy?

MR. ANDERSON.—No experiment was conducted in this particular series below 4.3 per cent aluminum. Since the minimum aluminum content is set by the casting qualities, as pointed out in the paper, we were interested only in determining whether the upper limit would be controlled by the physical properties and stability of the alloy. We feel that the results obtained demonstrate that the upper limit is dominated by the stability of the alloy.

---

[1] Assistant Sales Manager, St. Joseph Lead Co., New York City.

REPORT OF COMMITTEE B-7
ON
LIGHT METALS AND ALLOYS, CAST AND WROUGHT

Committee B-7 on Light Metals and Alloys, Cast and Wrought, has held two meetings since the submission of its report in 1932, one in Chicago, Ill., on June 30, 1933, and the other in Washington, D. C., on March 8, 1934. The committee has gained six new members, has lost six former members, and has had two new appointments to replace former representatives, leaving a total membership of 33, classified as 11 producer, 15 consumer, and 7 general interest members. Mr. J. B. Johnson has been appointed as the representative of Committee B-7 on the Non-Ferrous Metals Committee of the Society of Automotive Engineers.

In response to requests from the industry and in order to bring up to date its specifications covering light alloy products, Committee B-7 submitted to the Society during the past year, through Committee E-10 on Standards, one new tentative specification, five tentative specifications proposed as revisions of existing standards, and a revision of one existing tentative specification. The titles of these specifications are as follows:

Tentative Specifications for:

- Magnesium Ingot and Stick for Remelting (B 92 – 33 T);
- Aluminum Sheet and Plate (B 25 – 33 T), revision of existing standard;
- Aluminum-Base Alloy Sand Castings (B 26 – 33 T), revision of existing standard;
- Aluminum-Base Sand-Casting Alloys in Ingot Form (B 58 – 33 T), revision of existing standard;
- Aluminum-Alloy (Duralumin) Sheet and Plate (Aluminum-Copper-Magnesium-Manganese) (B 78 – 33 T), revision of existing standard;
- Aluminum-Manganese Alloy Sheet and Plate (B 79 – 33 T), revision of existing standard;
- Aluminum-Alloy (Duralumin) Bars, Rods and Shapes (Aluminum-Copper-Magnesium-Manganese) (B 89 – 33 T), revision of existing tentative standard.

The above recommendations were considered by Committee E-10 at a meeting held on August 16, 1933, and the specifications involved were accepted for publication as tentative and appear in the 1933

Proceedings.[1,2] Since five of the tentative specifications were extensive revisions of and were intended to supersede the five corresponding existing standards, the withdrawal of the standards was proposed and this recommendation was subsequently approved by the Executive Committee of the Society.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Standard.—In response to requests from industry, the committee is recommending for publication as tentative, as appended hereto,[3] proposed Tentative Specifications for Magnesium-Base Alloy Ingot for Remelting, as prepared by Subcommittee V.

II. Revisions of Tentative Standards.—The committee proposes revisions in the following five tentative specifications in order to make these specifications agree with present commercial practice. Minor changes are proposed in two of the specifications while extensive revisions are being made in the other three specifications. Attention is called to the change in scope of the Tentative Specifications for Magnesium-Base Alloy Wrought Shapes (Other than Sheet) (B 91 – 32 T) which are now limited to magnesium-base alloy forgings instead of covering all wrought shapes other than sheet. The committee recommends that these specifications, the titles of which are indicated below, be continued as tentative in their revised form:

Tentative Specifications for:

Aluminum Sheet and Plate (B 25 – 33 T),[4] revised as recommended by Subcommittee II;

Aluminum-Manganese Alloy Sheet and Plate (B 79 – 33 T),[4] revised as recommended by Subcommittee II;

Magnesium-Base Alloy Castings (B 80 – 31 T),[5] extensively revised as appended hereto,[6] recommended by Subcommittee V;

---

[1] In submitting these specifications to Committee E-10 on Standards, the committee reported the following results of the letter ballot vote of a total of 19 ballots returned from a committee membership of 33: Tentative Specifications for Magnesium Ingot and Stick for Remelting (B 92 – 33 T), 16 affirmative and none negative; Tentative Specifications for Aluminum Sheet and Plate (B 25 – 33 T), 16 affirmative and none negative; Tentative Specifications for Aluminum-Base Alloy Sand Castings (B 26 – 33 T), 18 affirmative and none negative; Tentative Specifications for Aluminum-Base Sand-Casting Alloys in Ingot Form (B 58 – 33 T), 18 affirmative and none negative; Tentative Specifications for Aluminum-Alloy (Duralumin) Sheet and Plate (Aluminum-Copper-Magnesium-Manganese) (B 78 – 33 T), 16 affirmative and none negative; Tentative Specifications for Aluminum-Manganese Alloy Sheet and Plate (B 79 – 33 T), 16 affirmative and none negative; Tentative Specifications for Aluminum-Alloy (Duralumin) Bars, Rods and Shapes (Aluminum-Copper-Magnesium-Manganese) (B 89 – 33 T), 17 affirmative and none negative.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 592 to 637 (1933); also 1933 Book of A.S.T.M. Tentative Standards, pp. 186 to 233.

[3] See p. 682.—ED.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 605 and 614 (1933); also 1933 Book of A.S.T.M. Tentative Standards, pp. 199 and 208.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 700 (1931); also 1933 Book of A.S.T.M. Tentative Standards, p. 229.

[6] See p. 684.—ED.

Magnesium-Base Alloy Sheet (B 90 – 32 T),[1] extensively revised as appended hereto,[2] recommended by Subcommittee V;

Magnesium-Base Alloy Wrought Shapes (Other than Sheet) (B 91 – 32 T),[1] extensively revised as appended hereto,[3] recommended by Subcommittee V.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 33 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Specifications for Magnesium-Base Alloy Ingot for Remelting	13	0	6
II. REVISIONS OF TENTATIVE STANDARDS			
Specifications for Aluminum Sheet and Plate (B 25 – 33 T)	15	0	4
Specifications for Aluminum-Manganese Alloy Sheet and Plate (B 79 – 33 T)	15	0	4
Specifications for Magnesium-Base Alloy Castings (B 80 – 31 T)	12	0	7
Specifications for Magnesium-Base Alloy Sheet (B 90 – 32 T)	13	0	6
Specifications for Magnesium-Base Alloy Wrought Shapes (Other than Sheet) (B 91 – 32 T)	13	0	6

ACTIVITIES OF SUBCOMMITTEES

Subcommittee II on Aluminum and Aluminum Alloy Wrought Shapes (P. V. Faragher, chairman).—The work of this subcommittee has consisted chiefly in the preparation of revisions, as indicated below, of the following two tentative specifications:

Tentative Specifications for Aluminum Sheet and Plate (B 25 – 33 T):[4]

Section 5.—In the table of tensile requirements, in the half-hard temper, change the elongations from 4, 5, 7, 9 and 10 to read 3, 4, 5, 7 and 7, respectively. The higher elongation values correspond to the quarter-hard temper which is not included in these specifications because of its infrequent use. Also, in the tabulation of thickness, change the maximum thickness for the three-quarter hard temper from the present value of "0.128 in." to read "0.162 in."

Tentative Specifications for Aluminum-Manganese Alloy Sheet and Plate (B 79 – 33 T):[4]

Section 5.—In the tabulation of thickness, change the maximum thickness for the three-quarter hard temper from the present value of "0.121 in." to read "0.162 in."

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 691 and 693 (1932); also 1933 Book of A.S.T.M. Tentative Standards, pp. 234 and 236.

[2] See p. 688.—ED.

[3] See p. 678.—ED.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 605 and 614 (1933); also 1933 Book of A.S.T.M. Tentative Standards, pp. 199 and 208.

Subcommittee IV on Aluminum-Base Casting Alloys (Sam Tour, chairman).—This subcommittee has been active in revising the standards and tentative standards under its jurisdiction and is cooperating with Subcommittee I on Aluminum-Base Die-Casting Alloys of Committee B-6 on Die-Cast Metals and Alloys in considering the advisability of preparing specifications for aluminum alloys in ingot form covering those compositions used in die castings.

Subcommittee V on Magnesium and Magnesium-Base Alloys, Cast and Wrought (J. A. Gann, chairman).—The work of this subcommittee has consisted in the preparation of the proposed Tentative Specifications for Magnesium-Base Alloy Ingot for Remelting and in the revision of the Tentative Specifications for Magnesium-Base Alloy Castings (B 80 - 31 T), for Magnesium-Base Alloy Sheet (B 90 - 32 T), and for Magnesium-Base Alloy Wrought Shapes (Other than Sheet) (B 91 - 32 T) as referred to earlier in this report. The specifications in their revised form are appended hereto.[1]

Subcommittee VI on Methods of Testing Light Alloys (R. L. Templin, chairman).—This subcommittee has been studying methods of determining the yield strength, Rockwell hardness and Brinell hardness of light metals. Committee B-7 has adopted the recommendation of this subcommittee to the effect that for light alloys a "set" value of 0.2 per cent be used in the yield strength determination made in accordance with the Standard Methods of Tension Testing of Metallic Materials (E 8 - 33)[2] where yield strength is defined as "the stress at which a material exhibits a specified limiting permanent set." This factor is now used in commercial work and in the recently revised tentative specifications for light metals and alloys.

Subcommittee VII on Service Characteristics of Light Metals and Methods of Protection Against Corrosion (E. H. Dix, Jr., chairman).—In order to obtain and assemble in brief and concise form authoritative information on the service characteristics and protection against corrosion of the light metals and alloys, Committee B-7 on Light Metals and Alloys, Cast and Wrought, appointed Subcommittee VII to undertake this compilation. The personnel of this subcommittee consists of the following:

A. L. Boegehold, General Motors Corp.
E. H. Dix, Jr., *Chairman*, Aluminum Company of America
J. A. Gann, The Dow Chemical Co.

---

[1] See pp. 684, 688 and 678.—ED.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

J. B. Johnson (*ex-officio*), Material Section, Materiel Divisior
Air Corps, U. S. A.
H. S. Rawdon, National Bureau of Standards
Sam Tour, Lucius Pitkin, Inc.

Later D. L. Colwell, of the Stewart Die Casting Corporation wa added to the committee and assisted Mr. Johnson in the collection c information on aluminum casting alloys.

The American Foundrymen's Association cooperated in this wor through their representative, T. D. Stay, who was especially helpfu in matters relating to the casting alloys. J. J. Bowman, associate c the chairman, compiled and edited the reports of the various member of the committee and collected much additional information, par ticularly that relating to the protection of aluminum alloys.

The report which appears in the Appendix represents the cul mination of two years' work. The report has been reviewed and it publication approved by the membership of Committee B-7.

The election of officers for the ensuing term of two years resulte in the selection of Sam Tour, chairman; E. H. Dix, Jr., vice-chairman and J. A. Gann, secretary.

This report has been submitted to letter ballot of the committe which consists of 33 members; 23 members returned their ballots c whom 22 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

J. B. JOHNSON,
Chairman.

J. A. GANN,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Magnesium-Base Alloy Ingo for Remelting were accepted for publication as tentative and appear on page 68

The revisions of the Tentative Specifications for Aluminum Sheet an Plate, for Aluminum-Manganese Alloy Sheet and Plate, for Magnesium-Bas Alloy Castings, for Magnesium-Base Alloy Sheet, and for Magnesium-Bas Alloy Wrought Shapes (Other than Sheet) were accepted. The specification in their revised form appear on pages 668 to 691, inclusive.

The report on "Service Characteristics of the Light Metals and thei Alloys," prepared by Subcommittee VII and referred to in the report wa approved for publication and appears in the Appendix, page 277.

APPENDIX

SERVICE CHARACTERISTICS OF THE LIGHT METALS AND THEIR ALLOYS

INTRODUCTION

This report has been prepared for the purpose of presenting to the engineer, in a brief and concise form, essential data for aluminum and magnesium and their alloys. For convenience in assembly, presentation, and use of these data, the report has been arranged in four parts: metallurgical characteristics, industrial requirements, surface protection, and tabular data.

It is readily apparent that only limited information can be given in such a brief report, with the hope of giving a general picture of the light metal field. To compensate partially for this and to make available to the interested reader more detailed information, a bibliography is appended.[1]

This report should be considered as a first edition, to be expanded and revised in subsequent editions. The alloys listed represent only those believed to be the more important—certainly not all—of the commercial alloys now in use. In later reports, it is planned to add alloys designed for more specific uses.

Readers are invited to submit to the Society's headquarters any data they believe should be included in subsequent revisions of the report.

METALLURGICAL CHARACTERISTICS

ALUMINUM AND ALUMINUM ALLOYS

Aluminum is a metal of low density which crystallizes in the cubic system. The grade usually used contains 99 per cent aluminum, although the metal is commercially available with a purity of 99.5 per cent and has been prepared with an aluminum content of 99.99 per cent; silicon and iron are the chief impurities in virgin metal. The physical properties of the pure metal are given in Table VIII.

Ingot aluminum is purchased on the basis of minimum aluminum content, although the Federal Specifications Board has adopted more rigorous specifications. Several grades are shown in Table VII. Ingots are notched and may be procured in 1 to 50-lb. sizes. Alloy ingots are differentiated by form, size and marking.

Aluminum alloys readily with many elements; bismuth, lead and cadmium being notable exceptions. The principal elements used for manufacturing commercial alloys are copper, silicon, iron, manganese, magnesium, zinc, chromium, titanium and nickel. Most o these elements have a profound effect on the properties of pur aluminum. The chemical composition of the common alloys used fo castings are given in Table IV and for wrought alloys in Table V.

---

[1] See p. 305.

Aluminum alloys may be cast in green or dry sand, permanen molds, or in the form of pressure die castings. Certain of the alloy used for sand casting are also used for castings produced by the othe processes while others have been developed for their specific process The choice of alloy, as well as process, will depend on the nature o the casting, the properties required, and the quantities involved.

As in the case with any cast metal, the mechanical properties i the cast state depend not only on chemical composition and hea treatment but on a variety of factors which influence the rate o solidification from the molten state: for example, melting and pouring temperatures, gating, type of mold, section thickness, rate of chilling etc. Consequently the strength of a commercial casting will usuall differ from that of separately cast test bars and will vary in differen parts of the casting. The test bar serves, however, to control th quality of the alloy and the heat treatment or other foundry practice to which the alloy is subjected.

Table X lists the typical mechanical properties of the mor common casting alloys. It will be noted that some of the alloys ar supplied in several heat-treated conditions to meet various engineerin requirements.

Most of the wrought alloys are commercially available in the form of plate, sheet, strip, foil, wire, rod, bar, tubing, forgings, extruded shapes, and rolled billets, bars and shapes. Several tempers, produced either by strain hardening or heat treatment, or a combination of the two, are normally available.

The mechanical properties of the more common wrought alloys in several tempers are given in Table XI. Those listed as Nos. 1, 2 and 3 are subject only to strain hardening and are often referred to as "common alloys." All the other alloys listed respond to heat treatment and are usually furnished by the producer in a heat-treated temper or in a temper involving a small amount of cold work subsequent to heat treatment. For convenience, these alloys are often classed as "strong alloys."

The tempers of the common alloys depend on the amount of cold work imposed upon them, such as by rolling, drawing, or spinning, and range from annealed to full-hard. The usual intermediate tempers are one-quarter, one-half, and three-quarters hard. The strength of the alloys increases with increased cold work but the elongation and workability are decreased. Some indication of the relative workability can be secured from the bend radii data of Table XIV. These alloys can be annealed from any temper by heating rapidly to the recommended annealing temperature (Table XIII) and cooling in air. Partial annealing of hard-rolled metal to secure intermediate tempers is not considered practical. These alloys if annealed can be rehardened only by further cold work.

Two types of treatment are commonly used to strengthen the heat-treatable alloys: the one is a high-temperature solution treatment, the other, a lower-temperature precipitation treatment, sometimes referred to as "artificial aging."

The high-temperature solution heat treatment is applied to all of the wrought alloys in this class and consists essentially of heating in a nitrate bath or an air furnace at temperatures which depend upon the composition of the alloy. Casting alloys are not always given a solution treatment, but when they are so treated the heating is carried out in an air furnace only. Relatively close control of the heat-treating temperature is necessary in order that the desired mechanical properties and corrosion resistance may be obtained without overheating or "burning" the metal. Exposure to temperatures above the upper limits given in the sixth column of Table XIII may cause a serious loss in ductility. The length of time the metal is in the nitrate bath or air furnace varies with its form, size, and shape, as well as the size and type of furnace and size of load, so any figure given here might be misleading.

The solution heat treatment of wrought alloys should be followed by a rapid quench in cold water as the slower quenches induced by hot water, air, or oil will somewhat impair the corrosion resistance by producing susceptibility to intercrystalline corrosion. Delay in transferring the metal from the furnace to the quenching tank should be held to the absolute minimum to prevent impaired corrosion resistance. In some cases, *castings* are quenched in boiling water or oil; sacrificing some corrosion resistance to minimize quenching stresses and distortion. Since the metal when at the heat-treating temperature is quite soft, some care in handling is necessary to avoid excessive warping.

The aluminum-copper-magnesium alloys of the duralumin type, such as 17S and some of its modifications, (Nos. 5, 6 and 7; Table V) age spontaneously at room temperature after having been given a solution heat treatment. This aging proceeds rather rapidly at first, but the rate decreases with time and the phenomenon is practically complete in four days. Experiments have shown th this aging can be retarded for extended periods by storing the hea treated material at 0 C. (32 F.), or below, and that normal aging w set in on removal from the low-temperature storage.

The other heat-treatable wrought alloys of Table V are ag at elevated temperatures, or in common terms, "artificially aged" secure maximum strength and hardness. Certain of the castin alloys are also given aging treatments to increase further their streng and hardness but, in contrast to the common procedure for wroug alloys, castings may sometimes be aged without a preceding soluti heat treatment. Aging is accomplished in steam chambers or an a furnace operating at temperatures of about 300 F. (150 C.). T aging period varies with the alloy and, to some extent (more so castings), with the combination of properties desired but is usual 12 to 18 or 24 hr. Accurate control of time and temperature is n so important in aging as in heat treating, but for consistently reliab results should not be subject to marked variations.

The wrought strong-alloys exhibit excellent workability in t heat-treated temper, but subsequent aging, either spontaneous artificial, somewhat reduces this property. On account of the reduc workability inherent in aged material, it is advisable to carry out a severe forming operations, such as heading rivets, in the interv between heat treating and aging. In the case of artificially ag alloys the time elapsing between heat treating and forming is not ve important but with duralumin or 17S (Nos. 5, 6 and 7; Table the more severe forming must be accomplished within a few hou after the material has been heat treated or removed from a lo temperature storage.

In general, the corrosion resistance of the wrought alloys in t heat-treated temper is somewhat lower than that usually associat with the common alloys and is usually further decreased by artific aging or other low-temperature reheating. In this latter connectio it should be noted that many of the treatments involved with bak finishes will produce some artificial aging in the strong alloys a may then reduce the corrosion resistance or mechanical properties both. The alloy listed as No. 14 in the wrought alloy tables is uniq in this respect, in that its corrosion resistance is excellent regardle of the temper.

The annealed temper of the strong alloys is available comme cially for use where ultimate workability is necessary and subseque heat treatment is practical. The strong alloys (except Nos. 13 a 14) in this temper have a relatively poor resistance to corrosion a should, therefore, never be placed in service without subsequent heat treatment. In some cases, rather difficult forming operations can be accomplished by heating the material to the heat-treating temperature and depending on the cold dies to secure a rapid quench.[1] This procedure will generally produce formed material with properties essentially equivalent to those in Table XI, but the corrosion resistance may be inferior to that of properly heat-treated material.

The strong alloys in any temper may be heat treated or reheat treated a reasonable number of times without deleterious effect and, if necessary, may be annealed from any temper by following the recommended procedure. If the alloy to be annealed is in the heat-treated temper the procedure which gives maximum workability is a "soak" for some time at about 800 F. (425 C.) and slow cool in the furnace to about 450 F. (230 C.) before removal to the air. To remove strain hardening from metal which has not been heat treated, or to secure fair workability in heat-treated material, annealing at 650 F. (345 C.) will be satisfactory.

Welding:

The wrought aluminum alloys are readily welded by experienced operators using either fusion or electric-resistance methods. Fusion welding of the strong alloys is not recommended in any case unless subsequent reheat treatment is possible. Fusion-welded joints have essentially a cast structure and hence are normally of lower unit strength than the welded sheet. With the commonly used welding materials, they are likewise not subject to improvement by heat treatment. The fusion processes are excellent for producing liquid-tight joints in the common alloys, but the joints in most cases are not so strong as the unwelded sheet. Spot and seam welding will produce consistently reliable joints when done on machines equipped with accurate electronic control. Subsequent reheat treatment is not necessary as the properties are not affected as in fusion welding.

Most casting alloys are also readily welded by fusion methods. The technique is somewhat more involved than for wrought alloys due to the possibility of thermal strains and cracks, but can be easily acquired by experience. Heat-treated castings should not be welded unless subsequent heat treatment is possible. Welding rod of the same composition as the casting is used in most cases and permits appreciable improvement in strength on heat treatment if it is of a heat-treatable alloy.

---

[1] U. S. Patent No. 1,751,500.

Soldering:

The soldering of aluminum and its alloys can be accomplish but is not recommended for highly stressed joints and the joint shou be given adequate protection to prevent localized corrosion.

MAGNESIUM AND MAGNESIUM ALLOYS

Magnesium is the lightest of our structural metals and many its industrial uses can be attributed primarily to this property. T metal is produced commercially in one grade only with a nomin purity of 99.9 per cent (average purity 99.94 per cent), the norm impurities being aluminum, iron, manganese, and silicon. A ve pure (99.99 per cent) distilled product is produced in limited quantiti for certain specific purposes such as the degasification of radio tub The commercial grade of metal as well as magnesium-base alloys a sold chiefly in the form of ingots 4 in. in diameter and 12 to 16 i long, weighing approximately 12 to 16 lb. each. The alloy ingo are differentiated by alloy identification and color marking.

Magnesium is used as a structural material only in the alloy form, never as the pure metal. It alloys readily with most of t common metals. Notable exceptions are iron, chromium, and certa related metals, which are practically insoluble in magnesium; a manganese which is soluble only to a limited extent, the solubili depending on the nature and amount of other alloying metals. T principal elements used for the production of commercial alloys a aluminum, manganese, zinc, tin, cadmium and copper. Each of the metals exerts a pronounced effect on the properties and casting fabricating characteristics of magnesium. Many of these effects a additive with the result that most magnesium-base alloys contai more than one added metal.

Magnesium alloy castings may be made in dry sand, green san permanent molds, and in both low- and high-pressure die-castin machines. Casting alloys containing 8 to 12 per cent aluminu (Nos. 1 to 3, Table VI) are susceptible to heat treatment with resulta property improvements. Solution heat treatment increases t tensile strength, percentage elongation, and toughness. Subseque precipitation heat treatment or aging increases the yield strength a hardness, and decreases the percentage elongation and toughne Magnesium casting alloys have properties comparable to those of t aluminum casting alloys.

Wrought alloys are available in various commercial form including plate, sheet, forgings, bars, rods, tubing, and structur shapes. These alloys are not subject to property improvement b heat treatment, hence the properties of such products are due to the alloy composition and to plastic flow of the metal either with or without accompanying strain hardening. Magnesium belongs to the closely packed hexagonal system and therefore hardens rapidly when subjected to small amounts of cold working. Maximum formability is obtained by working the metal warm or by frequent annealing when forming at room temperature.

The annealed sheet, of No. 6, Table XII, can be formed at room temperature using a bend radius of $3t$ (where t = thickness of sheet). The hard-rolled sheets, Nos. 6 and 7, require a bend radius of 5 to 10 t, the radius tending to increase directly with sheet thickness and amount of cold working. All sheet may be hot formed within the temperature range 500 to 750 F. (260 to 400 C.) using bend radii of 1 to 2 t.

Riveting (using standard aluminum alloy rivets) and welding are accomplished much the same on magnesium alloys as on aluminum alloys.

All magnesium alloys are noted for their remarkable machineability which is better than that of any other common metal. The cutting tools should be kept sharp, special care being taken that the clearance runs up to the cutting edge. The use of a lubricant or cutting compound is generally unnecessary due to the ease of machining and the slight generation of heat in ordinary machining operations. For details regarding machining and other phases of shop practice, manufacturers' publications may be consulted.

INDUSTRIAL REQUIREMENTS

All materials have certain inherent properties which must be considered in some way when determining the suitability of the material for a given use, the relative importance of the several properties varying with the proposed application. In the case of the light metals as a class, their weight, or strength-weight ratio, is a controlling factor in most of the applications in which they are used. The alloy chosen is then usually dictated by one or more of the other characteristics. The following discussion attempts to outline the reasons why light alloys are used in certain fields.

AIRCRAFT INDUSTRY

Aluminum and magnesium alloys are used in aircraft construction primarily because of their light weight or high strength-weight ratio. To function successfully, they must either resist the corrosive action of salt water and atmospheres or else admit of treatments which will resist these conditions. In those cases where the weight alone is t controlling factor, the strength-weight ratio of the alloy chosen mu equal or exceed that factor for other commercially available materi in order to justify their choice. In determining this factor, the weig of necessary protective coatings must be included as well as t mechanical stability of the completed structure, since to take a vantage of a high strength-weight ratio may in some cases result undesirably thin materials. Occasionally, design conditions arise which the modulus of elasticity of the light alloys requires the sacrifi of a part of the strength-weight ratio.

Requirements other than weight sometimes determine wh light metal or alloy is used, as in the case of pistons. The lower ur weight would dictate magnesium alloys for pistons but three oth important requirements are: (1) resistance to wear, (2) low therm expansion, and (3) high thermal conductivity. Because aluminu meets the requirements better with reference to these three requir ments it gives a better result even though some weight advantage sacrificed by its use. In the selection of the particular alloy of alum num to use for this part, these three properties are again the dete mining factors. In other words, the alloy with the highest therm conductivity, lowest coefficient of expansion and highest strength ar hardness at piston operating temperatures, along with satisfacto casting and machining properties, will be the one selected.

Structural parts such as struts, beams, wheel rims, fittings, wi covering, bolts, rivets and screw machine parts are all made fro rolled, forged, drawn or extruded aluminum alloy shapes. The all must be such as to permit as high a stress as possible and the particul alloy is determined also by its resistance to atmospheric corrosio although resistance to highly corrosive conditions is sometim obtained by application of organic coatings.

The alloy chosen for low-stressed parts such as tanks, cowlin streamline coverings, and minor fittings is usually dictated by t weldability, forming properties, corrosion resistance or machin ability. In these parts, the lower-strength, common alloys are usual employed.

Aluminum alloy castings are often used in many aircraft stru tures. Such castings should not, however, be used without a caref consideration of alloy, design, and strength requirements. Found technique and X-ray inspection can do much toward increasing t reliability of such parts. When properly designed and executed, su parts as wheel hubs, fittings, brackets, tail-wheel forks and misce laneous engine castings have proved very satisfactory.

Depending on the application and quantity desired, these parts may be produced as sand, permanent mold, or die castings. Sand casting is the most flexible process, applicable to a great variety of intricate parts produced in small or large quantities. Permanent-mold casting is generally confined to those parts required in some quantity, such as pistons and fittings, but will provide strengths somewhat in excess of those obtainable in sand castings. Die casting permits quantity production of parts with excellent surface appearance and requiring a minimum of finishing, but is generally used for parts which are not highly stressed in service.

Forgings of heat-treated aluminum alloys provide maximum strength and reliability. They are particularly reliable for the highly stressed parts of aircraft structures. Typical illustrations of forged products are propellers, crankcases, pistons, bearing supports, link rods and fittings.

For structures in which stiffness or rigidity are important, a high modulus of elasticity is desirable and for this reason, the light alloys are sometimes at a disadvantage when compared with steel. In such cases it is usually necessary to design parts so that the useful weight is as far from the centroid as is consistent with the practical requirement of stability. In sheets, this may be accomplished by corrugations, bumps or ribs.

Magnesium alloys are used to some extent in aircraft primarily for castings, such as wheels, brackets, housings, crankcases and various engine parts. There would be a more extensive use of these alloys, particularly in sheet form, were it not for certain limitations in their corrosion resistance. With the exception of salt atmospheres, their resistance to corrosion is generally good. Adequate paint protection will assure good corrosion resistance, even to salt atmospheres.

AUTOMOTIVE INDUSTRY

The automotive industry affords a large field for light alloy parts, both cast and wrought. Weight reduction, ease of fabricating and finishing, high thermal conductivity, appearance, and corrosion resistance are the principal considerations governing these applications.

Material weight reductions in commercial vehicles can be secured by the use of light alloys in the body, chassis, and fittings. Where a few years ago the use of these alloys in this field was limited to minor fittings, it has now been extended to the point where complete light-alloy construction is common. The weight thus saved in the bodies is used to reduce operating costs, increase pay-load or improve operating schedules. Some factors in addition to weight savings at times further promote the use of light alloys in this field, while consideration of firs cost, so important in pleasure cars, is reduced or eliminated b subsequent operating economies.

Material reduction in weight of many pleasure cars could b accomplished by the use of light alloys, but, except for a few cars i the higher-price fields, the present prices of these metals has confine their use to only certain parts where this requirement is urgent. A example of this is the piston. At high engine speeds, the velocity o this part fluctuates from zero to maximum at a very high frequency Light weight is therefore desirable to accomplish these rapid change with as little vibration as possible. Since piston inertia is a larg part of the load on connecting-rod bearings, light weight also reduce bearing loads and increases their life.

Engineering opinion differs somewhat as to the minimum siz aluminum alloy piston justified from the standpoint of weight savin and thermal properties. The larger the piston the more imperative i becomes to use aluminum, particularly since the high thermal conductivity is needed to keep the head of the piston cool enough t prevent pre-ignition and knocking.

The aluminum alloy selected for pistons must be one tha exhibits the necessary uniform strength and hardness at operatin temperatures, resists ring groove wear and deformation, and has goo bearing characteristics. The coefficient of expansion should be as lo as possible and the piston should attain dimensional permanence b simple, inexpensive treatments.

Crankcases and oil pans for automotive engines are frequentl made of light alloys, as a means of reducing engine weight. Th high thermal conductivity of aluminum results in lower crankcase oi temperature, which is desirable, and in some cases has made othe means of oil cooling unnecessary. The alloy selected should combine desirable casting characteristics with necessary strength and soundness.

Bearing caps must be made of light alloys when the crankcase is of these materials in order to maintain bearing concentricity. Forgings are most desirable for this application because of the strengths required, although heat-treated castings are sometimes used.

Aluminum alloys, on account of their high thermal conductivity are frequently used for cylinder-head castings. More uniform head temperatures result from their use, permitting higher compression ratios, increased power, and better volumetric efficiency concurrent with a cooler cylinder head. Semipermanent mold and sand castings of alloys suitable for pressure-tight castings and having satisfactory corrosion resistance are generally used.

The use of aluminum alloy brake shoes improves braking action because of their thermal conductivity and expansion. The corrosion resistance also is desirable since such parts must resist attack by water which gains admission to the mechanism. Although experience with magnesium alloys in these parts is lacking, proper design may result in satisfactory shoes of these alloys.

GENERAL STRUCTURAL WORK

Where lightness of structure is desirable, the additional requirements for general structural work are strength, stiffness and resistance to corrosion. Many types of structures where necessity for low weight makes it desirable to use aluminum or magnesium are subjected to special conditions which demand certain characteristics of the material used.

Almost invariably, the principal reason for using aluminum in structures is to save weight, as is well illustrated in dragline booms and buckets. With respect to the former, for instance, a composite boom in which the lower 35 ft. and some of the fittings were steel and the upper 140 ft. were aluminum, the total weight of the fully-rigged assembly was 29,000 lb.; 37 per cent less than the weight of a 150-ft. all-steel boom which it replaced. In general, all-aluminum construction permits a 15 to 20 per cent increase in length or a 20 to 25 per cent increase in bucket capacity, compared with steel booms. In the dragline bucket, a composite aluminum-steel construction will weigh about 50 per cent less than an all-steel one of the same capacity or, for the same gross weight loaded, the former has about a 33 per cent greater capacity. Another striking illustration is the all-aluminum floor system installed on a bridge in Pittsburgh. Here a weight saving of about 750 tons was effected by using 350 tons of aluminum; a saving both permitting a higher vehicle load limit and obviating the necessity of replacing the bridge for an estimated 25 years.

There are numerous other applications where lightness is of major consideration, such as, rotors for air motors, high-speed reciprocating machine parts, resonator horn disks, envelope folding machine parts, spools for winding wire, parts for vacuum cleaners, office machines, furniture, portable tools such as air hammers, breast drills and air-driven grinding wheels, wheelbarrows, concrete carts, foundry flasks, match plates and core boxes. For most of these applications, the alloy to be used is chosen for its mechanical properties, and resistance to severely corrosive conditions is improved by painting.

A great variety of uses for light metals also result from their low rate of reaction in various chemicals. A notable example of this is the use of magnesium for hydrofluoric acid containers. Until recently, paraffin or lead was used for these containers but magnesium now appears to be a superior material for the purpose. Other successful uses of magnesium are: equipment for manufacturing and storing certain types of organic chemicals, glue rollers and bakers oven peel and roll-type biscuit molds. Aluminum is proving successful for nitric and acetic acid containers, brewing equipment and beer barrels, rayon-spinning equipment, candy molds and dairy equipment.

ARCHITECTURAL WORK

The requirements for aluminum used in architectural work are: color, ability to take suitable finishes, corrosion resistance, and light weight for ease of erection. Examples of outside parts made of aluminum alloys, which must resist rather severe atmospheric corrosion in some localities, are windows and spandrels. These conditions may involve damp air, salt air, or sulfur-laden atmospheres in active industrial localities. Other outside fittings such as doors, flashings, cornices, marquees, ornamental crests, grilles, hardware, screens, screen frames and roof-type ventilators are also frequently made from aluminum to increase maintenance economy and reduce or eliminate stains on adjacent surfaces. Anodic coatings are now being applied to much outside architectural work, with the result that maintenance is practically avoided.

RAILWAY EQUIPMENT

The extensive use of aluminum in railway equipment has resulted from two chief factors: a desire for reduced weight, and the availability of the material in numerous forms and shapes. It is being used for all types of equipment, in applications varying from minor parts to complete cars or trains. All-aluminum hopper cars, tank cars and Pullman cars have been built which show material weight savings and have satisfactorily met service and safety requirements. Generally, the parts are protected by suitable finishes, but in some applications, transportation of sulfur or high-sulfur coal for instance, the inherent corrosion resistance of the metal is an advantage. Interior fittings, such as seat frames, doors, window frames and sashes, and interior finish panelling must be suitably finished for appearance and tarnish resistance. Hardware subject to contact with the hand must be treated to prevent staining and must not soil hands or gloves with which contact is made.

General structural members must possess high strength and are designed for suitable rigidity. These parts are rolled shapes or plates, extruded sections, castings and forgings. They require painting or other coating for complete protection against corrosion. With the advent of diesel engines as the power unit for drawing railroad trains, light alloys find additional applications. Upper and lower frames, bed plates, cylinder heads, blower and gear housings, cover plates, etc., are made of light alloys to reduce the weight-power ratio. Pistons for diesel engines are made of cast aluminum alloy but the duty is much more severe than in automobile or airplane engines. The larger mass of such pistons made light alloys desirable in reducing vibration and bearing loads.

HOUSEHOLD APPLIANCES

Aluminum alloys are used extensively for cast and wrought cooking utensils. For this purpose the requirements are good appearance, corrosion resistance, light weight, ability to polish well, and nonreaction with various foods cooked therein. The high thermal conductivity of aluminum alloys is useful in cooking utensils because it transfers the heat rapidly to all parts of the vessel resulting in more rapid heating. The same property makes it valuable for refrigerator trays for freezing ice cubes. The rapid heat transfer aids in removing the heat from the water. Ice cube trays being continually in contact with water or moisture are treated electrolytically to coat them with a thin layer of aluminum oxide. This makes the surface completely inert to any change over a long period of time.

One of the requirements for washing-machine parts and laundering equipment is that no rust shall form to spot the clothing. The nonrusting of aluminum alloys permits their use for these purposes. In addition its lightness is always desirable for any household article which must be handled or lifted.

Household furniture is required to be strong, light and pleasing in appearance. Aluminum and magnesium alloys are being used for this purpose. The articles of furniture are made from rolled, drawn or extruded sections which are welded together into any desired shape or form. The requirement of appearance is met by either using the natural metal color or by lacquering it in any desired way. The result is a very light piece of furniture which is more durable than a similar one made from wood.

The list of examples may be greatly extended but it is sufficient to state that any household article where either lightness, corrosion resistance, inertness to ordinary foods, or all three, are desired may be made from aluminum, and in some cases from magnesium alloys.

SURFACE PROTECTION

The light metals are sufficiently resistant to corrosion so that for most applications no surface protection is required. There are times, however, when surface protection or decoration is desirable, so some of the principles involved may be of interest. It is proposed to limit this discussion of surface protection to painting, anodizing, or the artificial production of a protective oxide coating, and electroplating. Of these methods, only painting is applicable to both metals; anodizing and electroplating apply specifically to aluminum.

PAINTING

The principles involved in the painting of aluminum and magnesium are very much the same except for the preparation of the metal surface. The paints used on one are usually satisfactory for the other. A discussion of the procedure to be followed can conveniently be broken down into three phases: surface preparation, priming coats and finishing coats.

A common type of paint failure on the light metals is blistering. This results from the liberation of gas between the metal surface and the paint film more rapidly than it can escape through the pores of the film. The formation of the gas (hydrogen) is induced by moisture penetrating the paint film and reacting with the metal. Two factors are, therefore, involved: the impermeability of the film, reducing the likelihood of appreciable moisture penetration; and the corrosion resistance or passivity of the metal surface. This latter factor can be controlled to a marked extent by proper surface preparation and the use of an inhibitive primer.

The surface of any metal must be free from oil, grease, and dirt prior to painting. The removal of oil and grease from both aluminum and magnesium is sometimes accomplished by the use of solvent cleaners, but more commonly by some chemical cleaner. The latter is more efficient for work on a commercial scale because the usual solvent cleaners retain the grease in solution and the subsequent evaporation of the thin film remaining on the metal after treatment again deposits a small amount of grease. In using the chemical cleaners, however, it is important that the metal be thoroughly washed and allowed to dry completely before paints are applied.

The chemical cleaners applicable to aluminum usually involve solutions of phosphoric acid and alcohol or those containing sodium phosphate and silicate. Numerous cleaners of these types are commercially available and are apparently very effective. The former type of solution seems to have a certain passivating effect, resulting from the formation of insoluble aluminum phosphate, in addition to its cleaning action. This passivation, while not as effective as an oxide coating (anodizing), is often quite satisfactory and less expensive.

The effectiveness of oxide coatings as a paint-base on aluminum will be only briefly described here, since these coatings are more fully discussed later. The most desirable coatings are those produced electrolytically, although chemically produced coatings such as provided by immersion in a boiling solution of potassium dichromate and sodium carbonate are suitable for some applications. The Bengough process electrolytic coating, produced by anodizing in a 3 per cent chromic acid solution under specified voltage and temperature conditions, is used extensively in the aircraft industry and has been found highly satisfactory. The newer "Alumilite" process, using a sulfuric acid bath, has also been extensively tested and is recommended as quite suitable.

The surfaces of magnesium and its alloys are freed from grease and oil by means of the commercial cleaners used for aluminum, or more effectively through the use of strong alkaline cleaners, as used for steel. Parts free from grease, and containing only a thin film of oxide, require no cleaning, inasmuch as such oxide films will be removed by the chrome-pickle treatment referred to below. Heavy scale or oxide coatings are removed by washing with commercial acid cleaners or by pickling in a 1 to 10 per cent sulfuric acid bath. Either type of cleaning must be followed by a thorough washing and drying.

To paint magnesium successfully, the surface of the metal must be given a chemical treatment. A number of such treatments are used commercially but the chrome-pickle (or acid-dichromate) treatment is most widely used in this country. It consists of immersing for a few minutes in a solution of sodium dichromate and nitric acid. The chrome-phosphate treatment is an alternative process and uses a solution of sodium dichromate and sodium dihydrogen phosphate but requires a longer immersion than the chrome-pickle treatment. Several other treatments are employed to some extent in Europe but their limited use in this country does not warrant their inclusion in this discussion.

In any case, the type of surface preparation to be used depends not only on the metal and character of the structure, but also on the subsequent service conditions. Although frequently considered indispensable, surface roughening by sand blasting or scratch brushing is believed somewhat overrated in so far as the light metals are concerned and is particularly to be used with caution on sheet in order to avoid warping. When used, it appears advisable to follow the roughening process by an oxide coating or chrome-pickle treatment.

Priming paints applicable to aluminum are generally suitable f magnesium and, as in the case of most metals, are probably the key a really satisfactory paint protection. Essentially, they should highly resistant to moisture penetration, should adhere well to t metal, should offer a good base for adherence of succeeding coats, a should contain corrosion inhibitive pigments.

Excluding the last requirement, it has been found that aluminu paint made with a good vehicle is a suitable priming paint. I adherence to the metal is satisfactory and it presents sufficient "tooth for succeeding coats. For general applications, this paint can be us for both primer and finish coats.

Zinc chromate and certain iron oxide - zinc chromate prime made up in a long-oil varnish vehicle make excellent corrosio inhibitive primers and are widely recommended and used. The vehic is an important factor in determining the moisture-proofing properti of paint coatings and, for the light alloys, should be more distensib than is necessary for steel. Some of the newer synthetic resin vehicle such as those made from Bakelite and glyceral-phthalate resins, a pear to be highly satisfactory. Tests have also indicated that bl lead and red lead primers can be used, but that they are general inferior to the aluminum paint and the inhibitive primers, especial where seams and joints are encountered.

Once the metal is properly primed, any durable exterior paint enamel may be employed for finishing coats. Here again, materi long in oil is especially recommended; any desired color can be applie When the color of natural aluminum is satisfactory, aluminum pai is frequently used. This paint has been found to give excelle protection to both aluminum and magnesium products under numero exposure conditions.

The synthetic-resin and the lacquer enamels have also bee found to offer excellent protection, particularly if a very elastic ty is used. The synthetic-resin finishes are especially recommend both for protection and high-grade finishing. The lacquers are little less effective than the synthetic resins on account of the tenden toward brittleness.

Good protection against severely corrosive conditions is secur by a schedule comprising one coat of an inhibitive primer and t coats of aluminum paint; all made up with a good vehicle. General speaking, a good paint coating may show about twice the durabili on aluminum and magnesium as on steel.

Clear finishes are sometimes desirable for the protection polished surfaces or various colored finishes. These coatings may either the lacquer or varnish types, but must be distensible and resistant to sunlight. Pyroxylin lacquers ordinarily lack this characteristic, although some of these lacquers which have been recently developed appear satisfactory. Varnishes of the modified glycerol-phthalate type generally show greater durability than the lacquers and adhere to the metal surface excellently. Certain vinyl resin varnishes have also given satisfactory results, but ordinary varnishes tend to yellow and are usually unsatisfactory. Coatings of a good wax are also sometimes used for structures subject to frequent maintenance, since they are readily removed and easily replaced.

Baked finishes are frequently used on the light metals and are considered very suitable on magnesium articles as they combine speed of finishing with excellent film characteristics. Those requiring high baking temperatures, however, should be used with discretion as they may result in undesirable precipitation hardening in certain alloys. A finish baked at lower temperatures can be used in such cases. Baking time should be, in all cases, as short as possible.

In all light-metal assemblies, the concealed or faying surfaces should be sealed or water proofed with some good protective paint and the design should avoid conditions promoting the retention of moisture. Faying surfaces between the light metal and any dissimilar metal, or wood, should, particularly, be insulated with a good paint. For this work the bituminous-base paints or asphaltic sealing compounds are frequently used, where their color is not objectionable, for their high moisture-proofing efficiency. Since these paints may bleed through subsequent coats, it is generally advisable to remove any excess that may be squeezed out of the joints. Where color is of importance, the bituminous paints may be pigmented with aluminum powder or aluminum paint used instead. Reinforced red lead is highly recommended as an insulating paint for magnesium but has not been found particularly desirable for aluminum.

OXIDE COATINGS

Aluminum always carries a thin, natural oxide coating which, without doubt, is responsible for the corrosion resistance of the metal. This natural coating, although thin, is quite impermeable and highly protective. Oxide coatings of substantial thicknesses can be artificially produced on aluminum by both chemical and electrochemical or electrolytic methods. The electrolytic or anodic coatings have proved very useful for many commercial applications.

The three generally-used methods for producing electrochemical coatings are primarily differentiated by the electrolytes used,—chromic acid, sulfuric acid and oxalic acid. Otherwise, the processes are similar, in that the article to be coated is made anode in a bath specified composition and at a closely controlled temperature.

In the formation of the oxide coating electrolytically, the actio takes place at the interface between the metal and the oxide alread formed. Theoretically, then, it is possible to form coatings of un limited thickness, provided the coating remains permeable to th electrolyte and permits the current to flow. Practically, however, th electrolytes have some solvent action on the oxide and the thickness i limited by chemical solution of the oxide. Nevertheless, coating several mils in thickness can be produced; but those used com mercially are generally less than one mil in thickness.

The chromic and sulfuric acid processes are most widely used i this country. They both produce coatings which provide an excellen base for paint as well as offering reasonably good protection in them selves. The sulfuric acid coating, however, is less expensive to apply is generally thicker, and is more resistant to abrasion.

X-ray evidence indicates that the anodic coatings are a amorphous form of aluminum oxide and, as formed, are somewha porous and adsorptive. They can be treated by certain so-calle "sealing" methods to change the structure and reduce this porosit with a consequent increase in impermeability and protective qualities The porous coatings will adsorb certain types of dyes, mineral pig ments, or corrosion inhibitors, greatly extending their useful properties This adsorbing power may be varied, of course, with the coatin methods used.

Until recently the coating applied in chromic acid has been use extensively in the aircraft industry as a base for paint, although nov being superseded in many cases by coatings applied in sulfuric aci and sealed with common inhibitors. This latter process provide improved corrosion resistance with added abrasion resistance, and may be used equally well for surface protection and various colo effects. The coatings have good dielectric properties and appear t have promise for use in electrical insulation, particularly where weight and space saving are desirable, or resistance to relatively high temperatures is of interest.

ELECTROPLATING

Aluminum can be readily electroplated with the common coating metals provided that the proper procedures are followed and some care in the choice of the base alloy and coating metal is exercised. Zinc and chromium can be plated directly on aluminum to produce a coating quite resistant to certain corrosive conditions while nickel followed by some other metal will produce a decorative coating which will resist abrasion and eliminate smudging. These duplex coatings, like most decorative coatings on other metals, are generally not very resistant to severe corrosion.

The proper preparation of the surface is probably the most important prerequisite to a satisfactory electroplate on aluminum. In this, the procedure varies to some extent with the alloy, product and proposed coating. Essentially, it consists of an alkaline cleaning, an acid dip, and a surface-roughing treatment.

The alkaline cleaning, considered more satisfactory than solvent cleaning, removes grease and oil and is usually carried out in a hot solution of sodium carbonate and trisodium phosphate. This cleaning is followed by a cold water rinse and a dip in hydrofluoric or nitric plus hydrofluoric acid. When only a small amount of grease, such as from finger marks, is on the surface, the alkaline cleaning may sometimes be omitted and only the acid dip used.

The metal surface, after these cleaning treatments, is generally considered "smooth" and apparently can be satisfactorily plated only with zinc or chromium. Either of these metals can be deposited on the "smooth" aluminum from ordinary plating solutions and will result in adherent coatings. The chromium deposit will come from the bath a dull gray color but, if produced in a cold (80 F.) solution, can be easily buffed and will effectively resist alkaline corrosion. The zinc deposit, from a cyanide bath, is also resistant to corrosion unless subsequently covered with another metal, such as copper or nickel.

For general use it is customary to apply first a layer of nickel and then the desired finish coat. In order to secure proper adherence of the plating a special surface-roughening treatment must first be employed. This roughening must be of a nature that will produce irregularities or pits having an undercut shape rather than merely an irregular surface as produced by sand blasting. Special etching solutions, which selectively dissolve certain constituents, have been developed for this purpose. They vary, of course, with the alloy and its form, but are essentially acid solutions with or without added metal salts. The time of dip varies to some extent and should be determined by testing the adherence of subsequently plated samples for different dipping times.

Plating on the roughened surface can be done from many different commercial baths. Nickel deposits from baths containing nickel sulfate, ammonium chloride, boric acid and either sodium or magnesium sulfate are highly satisfactory. These baths produce good deposits which can be readily buffed to a high luster. For moderate, outdoor service, a coating of 0.0005 to 0.001 in. is recommended Chromium, copper, brass, silver, and many other metals may b deposited over a nickel plate from the usually-used baths. Acid bath are preferable to cyanide baths for these final coatings since the latte tend to a certain extent to undermine the prior nickel plate.

TABULAR DATA

In the accompanying tables will be found three different sets o "item numbers," each beginning with No. 1. It will be found, however, that throughout all tables referring to the same class of material (as aluminum casting alloys) a given "item number" always describe the same alloy. This has been done so that future expansions of th tables referring to a given class of material will be by consecutiv numerical additions within that class. The reader is cautioned t bear in mind that the first column of each table gives *item number* and *not alloy numbers;* the more commonly used alloy specification numbers appearing in Tables I, II and III.

TABLE I.—TRADE DESIGNATIONS OF ALUMINUM CASTING ALLOYS.

Item	A.S.T.M.	S.A.E.	U. S. Army	U. S. Navy	Aluminum Company of America	Stewart Die Casting Corp.
No. 1	......	No. 30	57-72 grade 5	......	No. 12	......
No. 2	......	No. 31	......	......	......	......
No. 3	......	No. 31A	57-72 grade 8	......	No. 645	......
No. 4	Grade B[a]	No. 36	......	......	No. 212	......
No. 5	Grade C[a]	No. 33	57-72 grade 7	......	No. 112	......
No. 6	Grade E[a]	No. 32	......	......	No. 109	......
No. 7	Grade F[a]	No. 34	57-72 grade 6	......	No. 122	......
No. 8	Grade G[a]	No. 38	57-72-5	46A1c class 4	No. 195	......
No. 9	Grade GG[a]	......	......	......	No. 196	......
No. 10	Grade H[a]	No. 39	57-72-1A	......	No. 142	......
No. 11	Grade J[a]	No. 35	57-72 grade 1	46A1c class 2	No. 43	......
	No. IV[b]	No. 304	57-93-1	......	No. 43	No. 35
No. 12	Grade K[a]	No. 37	......	......	No. 47	......
	No. V[b]	No. 305	......	......	No. 13	No. 13
No. 13	......	No. 320	57-74-4	......	No. 214	......
No. 14	......	No. 321	......	......	No. 132	......
No. 15	......	No. 322	Air Corps 11307	......	No. 355	......
No. 16	......	No. 323	Air Corps 11308	46A1c class 3	No. 356	......
No. 17	......	No. 324	......	......	No. 220	......
No. 18	No. VI[b]	......	......	......	No. 83	......
No. 19	No. VII[b]	No. 307	......	......	No. 85	No. 10
No. 20	No. VIII[b]	......	......	......	......	......
No. 21	No. IX[b]	No. 309	......	......	No. 93	No. 5
No. 22	No. XII[b]	No. 312	57-93	......	No. 81	No. 12

---

[a] Classified according to the Tentative Specifications for Aluminum-Base Alloy Sand Castings (B 26 - 33 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 595 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 189.

[b] Classified according to the Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 - 33 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 641 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 254.

TABLE II.—TRADE DESIGNATIONS OF ALUMINUM WROUGHT ALLOYS.

Item	A.S.T.M.	S.A.E.	U. S. Army	U. S. Navy[e]	Federal Specifications Board	Aluminum Company of America	The Nicralumin Co. (Nicral)	Apex Smelting Co.
No. 1	[a]	No. 78 (25)	57-151-1	47A2a	QQ-A-561	2S	.....	....
				46A3b	QQ-A-411	......	.....	....
				44T19	WW-T-783	......	.....	....
No. 2	[b]	No. 29	....	47A4c	QQ-A-359	3S	.....	....
				46A6a	QQ-A-356	......	.....	....
				44T20a	WW-T-788	......	.....	....
				47A7	......	......	.....	....
No. 3	......	......	Air corps 11069	44T24	......	4S	.....	....
				47A9				
				46A8				
No. 4	......	......	....	....	......	14S	.....	....
No. 5	[c]	No. 26	57-153	47A3a	QQ-A-355	17S	.....	....
	[d]	......	....	46A4b	QQ-A-351	......	.....	....
	......	......	57-187-2	47T21	WW-T-786	......	.....	....
	......	......	57-152-2	47A6a	......	Alclad 17S	.....	....
				46A46				
				44T21a				
				44T22				
				46A7a				
				43R5				
				43B13				
No. 6	......	......	....	....	......	A 17S	.....	..
No. 7	......	......	....	....	......	B 17S	.....	....
No. 8	......	......	....	....	......	C 17S	.....	....
No. 9	......	......	....	....	......	18S	.....	....
No. 10	......	No. 24	Air corps 11066	47A10	......	24S	.....	....
			Air corps 11067 and 11071	47A8	......	Alclad 24S	.....	....
No. 11	......	No. 27	57-153	46A7a	......	25S	.....	....
No. 12	......	......	....	....	......	32S	.....	....
No. 13	......	No. 28	....	....	......	51S	.....	....
No. 14	......	......	....	....	......	53S	.....	....
No. 15	......	......	....	....	......	70S	.....	....
No. 16	......	......	....	....	......	......	.....	400
No. 17	......	......	....	....	......	......	A	
No. 18	......	......	....	....	......	......	B	
No. 19	......	......	....	....	......	......	X	

[a] Tentative Specifications for Aluminum Sheet and Plate (B 25 - 33 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 605 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 199.

[b] Tentative Specifications for Aluminum-Manganese Alloy Sheet and Plate (B 79 - 33 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 614 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 208.

[c] Tentative Specifications for Aluminum-Alloy (Duralumin) Sheet and Plate (Aluminum-Copper-Magnesium-Manganese) (B 78 - 33 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 610 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 204.

[d] Tentative Specifications for Aluminum-Alloy (Duralumin) Bars, Rods and Shapes (Aluminum-Copper-Magnesium-Manganese) (B 89 - 33 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 600 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 194.

[e] In addition to the specifications listed, several Navy Bureaus have tentative specifications.

TABLE III.—TRADE DESIGNATIONS OF MAGNESIUM ALLOYS, CAST AND WROUGHT.

Item	A.S.T.M.	U. S. Army	U. S. Navy	Dow Chemical Co. (Dowmetal)	American Magnesium Corp.	Bohn Aluminum and Brass Corp. (Bohnalite)
No. 0	[a]	57-21	....	Magnesium		
No. 1	Alloy 1[b]	57-74-lb grade 1	M-112c alloy 1	A	AM241	X-5
No. 2	Alloy 2[b]	57-74-lb grade 2	M-112c alloy 2	G	AM240	X-2
No. 3	Alloy 3[b]	....	....	B	AM246	X-7
No. 4	Alloy 4[b]	....	M-112c alloy 5	J	AM265	......
No. 5	Alloy 5[b]	....	M-112c alloy 3	T	......	X-4
No. 6	Alloy 6[c,d]	....	M-111b alloy 1	F	AM53S	X-1s
No. 7	Alloy 7[d]	....	....	E	......	X-3s
No. 8	Alloy 8[d]	....	M-126a grade 2	....	AM57S	......
No. 9	Alloy 9[d]	....	M-126a grade 3	....	AM58S	......
No. 10	Alloy 10[d]	....	M-126a grade 1	....	AM61S	X-11s
No. 11	Alloy 11[c]	....	M-111b alloy 2	M	AM3S	......

[a] Tentative Specifications for Magnesium Ingot and Stick for Remelting (B 92 - 33 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 636 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 232.

[b] Tentative Specifications for Magnesium-Base Alloy Sand Castings (B 80 - 34 T), see p. 684.

[c] Tentative Specifications for Magnesium-Base Alloy Sheet (B 90 - 34 T), see p. 688

[d] Tentative Specifications for Magnesium-Base Alloy Forgings (B 91 - 34 T), see p. 678.

TABLE IV.—NOMINAL COMPOSITION OF ALUMINUM CASTING ALLOYS.[a]

Item	Copper, per cent	Silicon, per cent	Magnesium, per cent	Zinc, per cent	Nickel, per cent	Iron, per cent
No. 1	8.0	....	....	....	....	....
No. 2	2.7	....	....	13.5	....	....
No. 3	2.5	....	....	11.0	....	1.5
No. 4	7.7	1.2	....	....	....	1.0
No. 5	7.0	2.0	....	2.0	....	1.2
No. 6	12.0	....	....	....	....	....
No. 7	10.0	....	0.2	....	....	1.2
No. 8	4.0	....	....	....	....	....
No. 9	4.0	....	0.3	....	....	....
No. 10	4.0	....	1.5	....	2.0	....
No. 11	....	5.0	....	....	....	....
No. 12	....	12.5	....	....	....	....
No. 13	....	....	3.75	....	....	....
No. 14	....	14.0	1.0	....	2.5	....
No. 15	1.25	5.0	0.5	....	....	....
No. 16	....	7.0	0.3	....	....	....
No. 17	....	....	10.0	....	....	....
No. 18	2.0	3.0	....	....	....	....
No. 19	4.0	5.0	....	....	....	....
No. 20	1.5	1.0	....	....	2.25	....
No. 21	4.0	1.75	....	....	4.0	....
No. 22	8.0	1.5	....	....	....	....

[a] Aluminum content = remainder.

TABLE V.—NOMINAL COMPOSITION OF ALUMINUM WROUGHT ALLOYS.[a]

Item	Silicon, per cent	Manganese, per cent	Copper, per cent	Nickel, per cent	Zinc, per cent	Magnesium, per cent	Other Elements, per cent
No. 1	....	99 per cent minimum aluminum					
No. 2	....	1.25	....	....	....	....	....
No. 3	....	1.25	....	....	....	1.0	....
No. 4	0.8	0.75	4.4	....	....	0.35	....
No. 5	....	0.5	4.0	....	....	0.5	....
No. 6	....	....	2.5	....	....	0.3	....
No. 7	....	....	3.5	....	....	0.3	....
No. 8	1.25	0.5	4.0	....	....	0.5	....
No. 9	....	....	4.0	2.0	....	0.5	....
No. 10	....	0.6	4.2	....	....	1.5	....
No. 11	0.8	0.8	4.5	....	....	....	....
No. 12	12.0	....	....	0.8	....	1.0	....
No. 13	1.0	....	....	....	....	0.6	....
No. 14	0.7	....	....	....	....	1.25	Chromium 0.25
No. 15	....	0.7	1.0	....	10.0	0.4	....
No. 16	....	0.5	....	....	....	3.8	....
No. 17	....	....	0.5	1.0	....	0.5	0.5[b]
No. 18	....	....	0.25	0.5	....	0.5	0.25[b]
No. 19	....	....	1.0	1.0	1.0	0.75	0.5[b]

[a] Aluminum content = remainder.

[b] These alloys contain chromium, manganese and molybdenum in about equal amounts; the sum of the three is shown; magnesium may be omitted.

TABLE VI.—NOMINAL COMPOSITION OF MAGNESIUM ALLOYS, CAST AND WROUGHT.[a]

Item	Aluminum, per cent	Manganese, per cent	Zinc, per cent	Copper, per cent	Cadmium, per cent	Tin, per cent
No. 0	99.9-per cent magnesium					
No. 1	8.0	0.2	....	....	....	....
No. 2	10.0	0.1	....	....	....	....
No. 3	12.0	0.1	....	....	....	....
No. 4	6.0	0.2	3.0	....	....	....
No. 5	2.0	0.2	....	4.0	2.0	....
No. 6	4.0	0.3	....	....	....	....
No. 7	6.0	0.3	....	....	....	....
No. 8	6.5	0.3	0.75	....	....	....
No. 9	8.5	0.2	0.5	....	....	....
No. 10	....	1.0	....	....	....	6.0
No. 11	....	1.5	....	....	....	....

[a] Magnesium content = remainder.

TABLE VII.—COMPOSITION OF ALUMINUM INGOT.

Item	Aluminum, per cent, min.	Copper, per cent, max.	Zinc, per cent, max.	Iron, per cent, max.	Silicon, per cent, max.	Manganese, per cent, max.	Magnesium, per cent, max.	Remarks
No. 1[a].....	98.0	....	....	....	....	....	....	For use in manufacture of iron and steel.
	94.0	....	0.5	....	....	....	....	
	90.0 (A Grade)	....	0.5	....	....	....	....	
	90.0 (B Grade)	....	4.0	....	....	....	....	
No. 2[b].....	99.5	0.10	....	....	....	....	....	For remelting.
	99.0	0.25	....	....	....	....	....	
	98.5	0.45	....	....	....	....	....	
No. 3[c].....	99.0	0.10	0.03	0.60	0.50	0.03	0.03	For remelting.
	98.0	....	0.2	(iron + silicon, 1.5, max.)		0.30	0.03	

[a] Standard Specifications for Aluminum for use in the Manufacture of Iron and Steel (B 37 - 26), 1933 Book of A.S.T.M. Standards, Part I, p. 868.

[b] Standard Specifications for Aluminum Ingots for Remelting (B 24 - 29), 1933 Book of A.S.T.M. Standards, Part I, p. 566.

[c] Federal Specification for Aluminum Ingots (QQ-A-451), Federal Specifications Board, Washington, D. C.

TABLE VIII.—PHYSICAL CONSTANTS OF ALUMINUM AND MAGNESIUM.

	Aluminum		Magnesium	
		Sample Purity, per cent		Sample Purity,[a] per cent
Atomic weight	26.97	......	24.32	......
Boiling point, deg. Cent	1800	......	1097	......
Crystal form	Face centered cubic	......	Close packed hexagonal	......
Mean coefficient of expansion, 20 to 300 C.	0.0000257	99.95 (cast)	0.0000283	......
Mean coefficient of expansion, 20 to 500 C.	0.0000277	99.95 (cast)	0.0000299	......
Density at 20 C. (68 F.), g. per cu. cm	2.70	99.971 (wrought-annealed)	1.74	......
Density at melting point (solid), g. per cu. cm	2.55	......	1.64	......
Density at melting point (liquid), g. per cu. cm	2.38	......	1.57	......
Electrical resistivity at 20 C.:				
Microhms per cu. cm	2.688	99.968 (hard drawn)	4.4611	......
Ohms per cir. mil ft. (A.I.E.E. standard)	17.01	Commercial	26.83	......
Temperature coefficient at 20 C. (A.I.E.E. standard)	0.00403	Commercial	0.0040	......
Electrical conductivity at 20 C.:				
Mass, per cent annealed copper	212.9	......	197.7	......
Volume, per cent annealed copper	64.6	......	38.6	......
Freezing point, deg. Cent	659.8	......	651	......
Heat of vaporization, cal. per g	1950 to 2000	......	1300 to 1500	......
Latent heat of fusion, cal. per g	93	......	70	......
Latent heat of fusion, B.t.u. per lb	169.16	......	126	......
Mechanical properties:				
Tensile strength, lb. per sq. in	9000	Annealed sheet 99.95	27 000	Commercial annealed sheet 99.8 to 99.9
Yield strength, lb. per sq. in. (Set = 0.2 per cent)	3000		10 000	
Elongation in 2 in., per cent	60		15	
Brinell hardness, 10-mm. ball, 500-kg. load	15		37	
Young's modulus of elasticity, lb. per sq. in	10 000 000	......	6 250 000	......
Modulus of rigidity (torsion), lb. per sq. in	3 870 000	Commercial	......	......
Poisson's ratio	0.33	......	......	......
Mean reflectivity, per cent for white light	87	......	73	......
Mean specific heat, cal. per g. (0 to 100 C.)	0.226	......	0.249	......
Thermal conductivity, c.g.s. units	0.52	99.66	0.37	......
Watts per sq. cm. per cm. per deg. Cent	2.17	99.66	1.55	......
B.t.u. per sq. ft. per in. per deg. Fahr. per hr	1509	......	1102	......

[a] Unless otherwise noted the magnesium used in the determination of many of the above properties had a purity of 99.9 to 99.99 per cent. Metal of approximately the same purity was probably used in the determination of the other properties, although the literature is silent on this point.

TABLE IX.—PHYSICAL PROPERTIES OF MAGNESIUM ALLOYS.

Item	Condition[a]	Specific Gravity	Weight, lb. per cu. in.	Melting Range		Coefficient of Thermal Expansion, 65 to 750 F.	Thermal Conductivity, c.g.s. units, 100 to 300 C.	Electrical Resistivity, michroms per cu. cm., at 20 C. (68 F.)
				deg. Fahr.	deg. Cent.			
No. 1...	Sand cast	1.80	0.065	1120–815	605–435	0.000016	0.18	13.0
	Sand cast H. T. 1	1.80	0.065	1120–815	605–435	0.000016	....	15.0
No. 2...	Sand cast	1.81	0.066	1100–815	595–435	0.000016	0.17	15.0
	Sand cast H. T. 1	1.81	0.066	1100–815	595–435	0.000016	....	17.5
	Sand cast H. T. 2	1.81	0.066	1100–815	595–435	0.000016	....	16.0
	Sand cast H. T. 3	1.81	0.066	1100–815	595–435	0.000016	....	14.0
No. 3...	Sand cast H. T. 3	1.82	0.066	1070–815	575–435	0.000016	0.16	14.0
No. 4...	Sand cast	1.84	0.066	1155–750	625–400	0.000016	....	....
No. 5...	Sand cast	1.86	0.067	1185–1050	640–565	0.000016	0.30	6.5
No. 6...	Extruded	1.77	0.064	1160–815	625–435	0.000016	0.23	10.0
No. 7...	Extruded	1.79	0.065	1140–815	615–435	0.000016	0.20	13.0
No. 8...	Extruded	1.81	0.065	1155–	625–	0.000016	....	....
No. 9...	Forged	1.83	0.066	....	...	....	....	....
No. 10...	Forged	1.85	0.067	....	...	....	....	....
No. 11...	Extruded	1.76	0.064	1200	650	0.000016	0.30	5.0

[a] H. T. 1 = Solution heat treatment.
H. T. 2 = Solution heat treatment + partial aging.
H. T. 3 = Solution heat treatment + complete aging.

TABLE X.—TYPICAL MECHANICAL PROPERTIES OF ALUMINUM CASTING ALLOYS.[a]

Modulus of elasticity is 10,000,000 lb. per sq. in.

Item	Temper[b]	Tensile Strength, lb. per sq. in.	Yield Strength (Set = 0.2 per cent), lb. per sq. in.	Elongation in 2 in., per cent	Brinell Hardness Number[c]	Shearing Strength, lb. per sq. in.	Charpy Impact, ft-lb.[d]	Compressive Strength, lb. per sq. in.[e]	Endurance Limit, lb. per sq. in.[f]	Density
No. 1......	AC	22 000	14 000	2.0	65	20 000	0.70	38 000	7 500	0.102
No. 2......	AC	25 000	......	1.0	......	....	....	......	......	......
No. 3......	AC	29 000	22 000	4.0	70	22 500	2.00	50 000	7 500	0.106
No. 4......	AC	22 000	14 000	2.0	65	20 000	0.70	38 000	7 500	0.102
No. 5......	AC	22 000	14 000	2.0	70	20 000	0.59	44 000	8 500	0.103
No. 6......	AC	24 000	18 000	1.5	75	20 000	0.63	45 000	10 000	0.105
No. 7......	HT–A	36 000	30 000	1.0	100	29 500	0.68	80 000	......	0.103
No. 8......	HT	31 000	16 000	8.0	65	27 000	2.80	43 000	6 000	0.100
	HT–A	36 000	22 000	4.0	80	29 000	1.80	43 000	6 000	0.100
No. 9......	HT–A	38 000	34 000	1.0	100	34 000	1.81	64 000	6 500	0.100
No. 10......	AC	28 000	24 000	1.0	85	24 000	0.62	52 000	8 000	0.100
	HT–A	37 000	......	0.5	100	32 000	0.59	70 000	8 000	0.100
No. 11......	AC	19 000	9 000	4.0	40	15 000	0.98	25 000	6 500	0.096
	AC*	29 000	12 000	3.5	......	......	4.50	......	......	......
No. 12......	Modified	26 000	11 000	8.0	50	18 000	3.00	28 000	6 000	0.095
	AC*	33 000	16 000	1.5	80	......	2.00	......	......	......
No. 13......	AC	25 000	12 000	9.0	50	19 000	3.80	50 000	5 500	0.095
No. 14......	HT–A	......	......	......	......	......	......	......	......	......
No. 15......	HT	30 000	20 000	4.0	60	30 000	1.26	65 000	......	0.097
	HT–A	35 000	27 000	2.0	80	30 000	1.08	68 000	......	0.097
No. 16......	HT	28 000	16 000	6.0	55	22 000	1.65	46 000	......	0.095
	HT–A	32 000	22 000	4.0	70	23 000	1.00	48 000	8 000	0.095
No. 17......	HT	44 000	26 000	13.0	75	33 500	4.50	72 500	7 500	0.092
No. 18......	AC*	30 000	13 000	3.5	100	......	5.00	......	......	......
No. 19......	AC*	32 000	18 000	2.0	60	......	2.50	......	......	......
No. 20......	AC*	29 000	......	4.0	......	......	4.50	......	......	......
No. 21......	AC*	21 000	19 000	1.5	80	......	2.00	......	......	......
No. 22......	AC*	33 000	25 000	1.0	80	......	1.50	......	......	......

[a] Tension test results obtained on standard $\frac{1}{2}$-in. diameter, sand-cast bars except where marked with a asterisk (*) in "temper" column, in which case they were $\frac{1}{4}$-in. diameter die-cast bars.

[b] AC = as cast; HT = heat treated; HT-A = heat treated and aged.

[c] 500-kg. load, 10-mm. ball.

[d] The Charpy impact values for sand castings are from bars 10 mm. square and having a noted 5 mm. deep with a 1 mm. radius at the bottom; for die castings, a $\frac{1}{4}$-in. square bar, 3 in. long and with a notch, was used.

[e] Specimens having l/r ratio of 16 to 20. All failed by lateral bending.

[f] R.R. Moore type machine — 500,000,000 cycles.

TABLE XI.—TYPICAL MECHANICAL PROPERTIES OF ALUMINUM WROUGHT ALLOYS.[a]

Modulus of elasticity is 10,000,000 lb. per sq. in.

Item	Temper[b]	Material Tested	Tensile Strength, lb. per sq. in.	Yield Strength (Set = 0.2 per cent), lb. per sq. in.[c]	Elongation in 2 in., per cent	Brinell Hardness Numbers[d]	Rockwell Hardness Numbers[e]	Shearing Strength, lb. per sq. in.[f]	Endurance Limit, lb. per sq. in.[g]
No. 1	O	Rod	13 000	4 000	40	23	S-23	9 500	5 000
	½H		17 000	14 000	20	32	E-22	11 000	7 000
	H		24 000	21 000	10	44	E-43	13 000	8 500
No. 2	O		16 000	5 000	40	28	S-52	11 000	7 000
	½H		21 000	18 000	20	40	E-51	14 000	9 000
	H		29 000	25 000	10	55	E-68	16 000	10 000
No. 3	O		26 000	10 000	20	45	E-51	16 000	14 000
	½H		35 000	31 000	10	65	E-77	19 000	15 000
	H		42 000	38 000	5	80	E-88	22 000	16 000
No. 4	O		27 000	11 000	23	44	E-51	18 000	10 500
	W		62 000	38 500	25	106	E-98	40 500	15 000
	T		69 000	53 000	18	125	E-104	44 500	15 500
No. 5	O		26 000	10 000	20	45	E-54	18 000	11 000
	T		58 000	35 000	20	100	E-96	35 000	15 000
	RT		63 000	46 000	13	110	E-98	36 000	......
	Alclad T	Sheet	55 000	32 000	18	...	......	32 000	......
	Alclad RT	Sheet	55 000	40 000	11	...	......	33 000	......
No. 6	O	Rod	22 000	8 000	22	38	E-37	15 000	......
	T		40 000	22 000	22	70	E-79	25 000	13 500
No. 7	O		22 000	8 000	22	38	E-37	15 000	......
	T		48 000	25 000	20	85	E-87	29 000	15 000
No. 8	O		28 000	12 000	18	48	E-54	19 000	......
	T		65 000	52 000	10	118	E-100	37 000	13 500
No. 9	W		54 000	31 000	20	91	E-92	34 000	......
	T		57 000	36 000	10	100	......	......	......
No. 10	T		65 000	43 000	20	105	E-97	40 000	14 000
	RT		68 000	53 000	13	116	E-99	41 000	14 500
	Alclad T	Sheet	60 000	40 000	18	...	......	39 000	......
	Alclad RT	Sheet	62 000	49 000	11	...	......	39 000	......
No. 11	O	Rod	26 000	10 000	20	45	E-54	18 000	9 000
	W		48 000	25 000	18	85	E-87	29 000	14 500
	T		58 000	35 000	20	100	E-96	35 000	15 000
No. 12	T		55 000	46 000	6	98	E-94	38 000	14 000
No. 13	O		16 000	6 000	30	28	S-52	11 000	6 500
	W		35 000	20 000	24	65	E-75	24 000	10 500
	T		48 000	38 000	14	95	E-92	32 000	10 500
No. 14	O		16 000	6 000	30	28	S-52	10 000	7 500
	H		28 000	26 000	8	48	E-56	18 000	......
	W		32 000	19 000	25	60	E-75	23 000	......
	T		35 000	28 000	20	74	E-83	24 000	11 000
No. 15	T		56 000	48 000	18	98	E-94	37 000	21 000[h]
No. 17	O	Sheet	21 000	8 500	20	...	S-72	......	......
	2		26 000	24 500	5	...	S-90	......	......
	H		38 000	35 500	4	...	E-80	......	......
	CO		28 500	15 500	20	...	S-88	......	......
	DO18		45 000	38 000	9	...	E-91	......	......
	D2012		46 000	40 500	10	...	E-91	......	......
	D6418		53 000	51 000	3	...	E-95	......	......
No. 18	O		17 000	6 500	26	...	S-58	......	......
	2		22 000	20 500	8	...	S-81	......	......
	H		34 500	32 500	4	...	E-73	......	......
	CO		18 500	9 600	26	...	S-71	......	......
	DO8		40 000	32 000	13	...	E-85	......	......
No. 19	MO		25 500	11 500	20	...	S-81	......	......
	CO		44 500	27 000	21	...	E-84	......	......
	D2018		57 000	48 500	10	...	E-102	......	......
	D4418		65 500	64 000	2	...	E-104	......	......
	DO18	Rod	55 000	42 000	17	...	......	......	......

---

[a] Tension test results obtained on standard A.S.T.M. ½-in. diameter specimens except where noted as sheet ($\frac{1}{16}$ in. thick) specimens.

[b] O = Annealed.
½H = Half hard.
H = Hard.
2 = Intermediate temper.
D 2018 or D 2012 = Heat treated, rolled and aged.
D 4418 or D 6418 = Heat treated, rolled, aged and rolled.
W or CO = Solution heat treated.
T or DO = Heat treated and aged.
RT = Heat treated, aged and cold rolled.
MO = Heat treatable.

[c] Yield strength in compression is practically the same as in tension.

[d] 500-kg. load on 10-mm. ball.

[e] S = 60-kg. major load on ⅛-in. ball; E = 100-kg. major load on ⅛-in. ball.

[f] Single shear values from double shear tests.

[g] R. R. Moore type rotating-beam machine; 500,000,000 cycles.

[h] Estimated from incomplete results.

TABLE XII.—TYPICAL MECHANICAL PROPERTIES OF MAGNESIUM ALLOYS, CAST AND WROUGHT.

Modulus of elasticity is 6,500,000 lb. per sq. in.

Item	Condition[a]	Tensile Strength, lb. per sq. in.[b]	Yield Strength (Set = 0.2 per cent), lb. per sq. in.[c]	Elongation in 2 in., per cent	Brinell Hardness Numbers[d]	Rockwell Hardness Numbers, "E" Scale	Compressive Strength, lb. per sq. in.	Shearing Strength, lb. per sq. in.	Charpy Impact, ft-lb.	Endurance Limit, lb. per sq. in.
No. 1 ..	Sand cast	25 000	11 000	4	48	55	46 000	17 000	0.9	7 000
	Sand cast H. T. 1	33 000	11 000	9	48	55	46 000	17 000	2.2	7 500
No. 2...	Die cast	29 000	20 000	1	63	75	......	......	...	......
	Sand cast H. T. 1	33 000	12 000	7	51	61	51 000	20 000	2.0	11 500
	Sand cast H. T. 2	33 000	16 000	3	60	72	51 000	21 000	1.0	10 000
	Sand cast H. T. 3	33 000	19 000	1	69	80	55 000	22 000	0.7	10 500
No. 3...	Sand cast H. T. 3	29 000	21 000	0.5	75	84	55 000	18 000	...	......
No. 4...	Sand cast	28 000	11 000	5	48	55	46 000	19 000	1.0	7 000
No. 5...	Sand cast	24 000	8 000	6	40	34	39 000	15 000	...	6 000
No. 6...	Extruded[f]	40 000	26 000	15	48	55	58 000	20 000	2.2	13 000
	Forged	38 000	23 000	12	50	60	......	......	...	12 000
	Sheet	43 000	30 000	8	65	76	......	......	...	......
	Sheet annealed	35 000	19 000	14	55	66	......	......	...	......
No. 7...	Extruded[f]	42 000	30 000	14	53	64	61 000	21 000	...	16 000
	Forged	38 000	23 000	12	52	62	......	......	...	12 000
No. 8...	Extruded[f]	43 000	28 000	15	55	66	54 000	22 000	2.0	16 000
	Forged	42 000	28 000	9	59	71	......	......	2.2	......
No. 9...	Forged	45 000	32 000	6	72	82	40 000	23 000	1.4	16 000
No. 10...	Forged	35 000	19 000	5	45	49	......	......	2.0	9 000
No. 11...	Extruded[f]	42 000	26 000	7	42	40	57 000	19 000	...	7 000
	Sheet	33 000	21 000	6	50	60	......	......	...	......

[a] H. T. 1 = Solution heat treatment.
H T 2 = Solution heat treatment + partial aging.
H. T. 3 = Solution heat treatment + complete aging.

[b] Tension specimens are according to A.S.T.M. Tentative Specifications for Magnesium-Base Alloy Sand Casting (B 80 - 34 T); for Magnesium-Base Alloy Sheet (B 90 - 34 T); for Magnesium-Base Alloy Forgings (B 91 - 34 T and for Magnesium-Base Alloy Ingot for Remelting (B — - 34 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part (1934); also 1934 Book of A.S.T.M. Tentative Standards.

[c] Yield strength is defined as the stress at which the stress-strain curve deviates 0.2 per cent from the modulus lin

[d] Brinell hardness is obtained with 500-kg. load, 10-mm. ball.

[e] R. R. Moore type rotating-beam machine—500 million cycles.

[f] Properties of extruded material for round and square up to 1½ in.

[g] Approximate value.

TABLE XIII.—FABRICATING CHARACTERISTICS OF ALUMINUM WROUGHT ALLOYS.

Item	Welding[a]		Machining	Polishing and Buffing	Heat Treatment[d]		Mechanical Working[a]					
	Gas	Electric Arc			deg. Fahr.	deg. Cent.	Operation	Temperature	Ease of Working			
									Annealed	Half Hard	Hard	Heat Treat ed
Nos. 1 to 3..	Yes	Yes	Good[c]	Good	Anneal[d]	Anneal[d]	Drawing	Cold	Excellent	Good	Fair	....
No. 4......	[b]	Yes	Good[c]	Good	920–940	495–505	Drawing	[g]	......	....	...	Good
No. 5......	[b]	Yes	Good[c]	Good	930–950	500–510	Drawing	[g]	......	....	...	Good
No. 6......	[b]	Yes	Good[c]	Good	930–950	500–510	Drawing	[g]	......	....	...	Good
No. 7......	[b]	Yes	Good[c]	Good	930–950	500–510	Drawing	[g]	......	....	...	Good
No. 8......	[b]	Yes	Good[c]	Good	920–940[f]	495–505[f]	Drawing	[g]	......	....	...	Good
No. 9......	[b]	Yes	Good[c]	Good	950–970	510–520	Forging	Hot	......	....	...	Good
No. 10......	[b]	Yes	Good[c]	Good	910–930	490–500	Drawing	[g]	......	....	...	Good
No. 11......	[b]	Yes	Good[c]	Good	960–980[e]	515–525[e]	Forging	Hot	......	....	...	Good
No. 12......	[b]	Yes	Good[c]	Good	950–970	510–520	Forging	Hot	......	....	...	Good
No. 13......	[b]	Yes	Good[c]	Good	960–980[f]	515–525[f]	Drawing	[g]	......	....	...	Good
No. 14......	Yes	Yes	Good[c]	Good	960–980[f]	515–525[f]	Drawing	[g]	......	....	...	Good
No. 15......	[b]	Yes	Good[c]	Good	870–890	465–475	Forging	Hot	......	....	...	Good
No. 16......	Yes	Yes	Good[c]	Good	None	None	....	....	......	....	...	....
Nos. 17 to 19	Yes	Yes	Good[c]	Good	940–960[h]	505–515[h]	Drawing	[g]	......	....	...	Very Good

[a] For details, consult manufacturer.

[b] Gas welding these alloys generally not recommended.

[c] With proper tools.

[d] Alloy 1 anneals at 650 F. (345 C.); 2 and 3 at 750 F. (400 C.).

[e] Age 8 to 15 hours at 290 F. (145 C.) for maximum strength.

[f] Age 18 hours at 320 F. (160 C.) for maximum strength.

[g] Hot or cold depending on job.

[h] May be aged 8 to 24 hours at 290 to 310 F. (145 to 155 C.).

TABLE XIV.—TYPICAL BEND RADII FOR 180-DEG. COLD BEND FOR WROUGHT ALUMINUM ALLOYS.

Item	Temper	$\frac{1}{64}$-in. Sheet	$\frac{1}{32}$-in. Sheet	$\frac{1}{16}$-in. Sheet	$\frac{1}{8}$-in. Sheet	$\frac{3}{16}$-in. Sheet	$\frac{1}{4}$-in. Sheet
No. 1...........	O	0 rad.	0 rad.	0 rad.	0 rad.	0 rad.	0 rad.
	$\frac{1}{2}$ H	0 rad.	0 rad.	0 rad.	0 rad.	0 rad.	0 to $1t$
	H	0 to $1t$	0 to $1t$	0 to $1t$	$\frac{1}{2}$ to $1\frac{1}{2}t$	....	....
No. 2...........	O	0 rad.	0 rad.	0 rad.	0 rad.	0 rad.	0 rad.
	$\frac{1}{2}$ H	0 rad.	0 rad.	0 rad.	0 to $1t$	0 to $1t$	$\frac{1}{2}$ to $1\frac{1}{2}t$
	H	0 to $1t$	0 to $1t$	$\frac{1}{2}$ to $1\frac{1}{2}t$	1 to $2t$	....	....
No. 3...........	O	0 rad.	0 rad.	0 rad.	0 rad.	0 rad.	0 rad.
	$\frac{1}{2}$ H	0 to $1t$	$\frac{1}{2}$ to $1\frac{1}{2}t$	1 to $2t$	$1\frac{1}{2}$ to $3t$	3 to $5t$	4 to $6t$
	H	$1\frac{1}{2}$ to $3t$	2 to $4t$	3 to $5t$	4 to $6t$	....	....
No. 5...........	O	0 rad.	0 rad.	0 rad.	0 to $1t$	$\frac{1}{2}$ to $1\frac{1}{2}t$	1 to $2t$
	T	$\frac{1}{2}$ to $1\frac{1}{2}t$	1 to $2t$	$1\frac{1}{2}$ to $3t$	2 to $4t$	3 to $5t$	4 to $6t$
	RT	$1\frac{1}{2}$ to $3t$	2 to $4t$	3 to $5t$	4 to $6t$	4 to $6t$	....
No. 6...........	O	0 rad.	0 rad.	0 rad.	0 rad.	0 rad.	0 to $1t$
	T	0 to $1t$	0 to $1t$	$\frac{1}{2}$ to $1\frac{1}{2}t$	1 to $2t$	$1\frac{1}{2}$ to $3t$	2 to $4t$
No. 7...........	O	0 rad.	0 rad.	0 rad.	0 rad.	0 to $1t$	0 to $1t$
	T	0 to $1t$	$\frac{1}{2}$ to $1\frac{1}{2}t$	1 to $2t$	1 to $2t$	$1\frac{1}{2}$ to $3t$	2 to $4t$
No. 10...........	O	0 rad.	0 rad.	0 rad.	0 to $1t$	$\frac{1}{2}$ to $1\frac{1}{2}t$	1 to $2t$
	T	1 to $2t$	$1\frac{1}{2}$ to $3t$	2 to $4t$	3 to $5t$	4 to $6t$	4 to $6t$
	RT	2 to $4t$	3 to $5t$	3 to $5t$	4 to $6t$+	4 to $6t$+	....
No. 13...........	O	0 rad.	0 rad.	0 rad.	0 rad.	0 rad.	0 rad.
	W	0 to $1t$	$\frac{1}{2}$ to $1\frac{1}{2}t$	$\frac{1}{2}$ to $1\frac{1}{2}t$	$1\frac{1}{2}$ to $3t$	2 to $4t$	3 to $5t$
	T	2 to $4t$	3 to $5t$	3 to $5t$	4 to $6t$	....	....
No. 14...........	O	0 rad.	0 rad.	0 rad.	0 rad.	0 rad.	0 rad.
	H	0 to $1t$	0 to $1t$	$\frac{1}{2}$ to $1\frac{1}{2}t$	1 to $2t$	....	....
	W	0 to $1t$	$\frac{1}{2}$ to $1\frac{1}{2}t$	$\frac{1}{2}$ to $1\frac{1}{2}t$	$1\frac{1}{2}$ to $3t$	2 to $4t$	3 to $5t$
	T	2 to $4t$	3 to $5t$	3 to $5t$	4 to $6t$	....	....
No. 17...........	O	....	....	0 rad.	....	....	....
	2	....	....	0 rad.	....	....	....
	H	....	....	2 to $4t$	....	....	....
	CO	....	....	0 rad.	....	....	....
	D 018	....	....	$1\frac{1}{2}$ to $3t$	....	....	....
	D 2012	....	....	$1\frac{1}{2}$ to $3t$	....	....	....
	D 6418	....	....	4 to $6t$	....	....	....
No. 18...........	O	....	....	0 rad.	....	....	....
	2	....	....	0 rad.	....	....	....
	H	....	....	2 to $4t$	....	....	....
	CO	....	....	0 rad.	....	....	....
	D 08	....	....	$1\frac{1}{2}$ to $3t$	....	....	....
No. 19...........	MO	....	....	....	....	0 rad.	....
	CO	....	....	$1\frac{1}{2}$ to $3t$	....	....	....
	D 2018	....	....	4 to $6t$+	....	....	....
	D 4418	....	....	3 to $5t$	....	....	....

NOTE.—t = thickness of sheet.

TABLE XV.—FOUNDRY CHARACTERISTICS OF ALUMINUM CASTING ALLOYS.

Item	Type		Standard Condition Heat Treatment			Solidification Range		Fluidity[a]	Hot Shortness[a]	Welding[a]	Soldering[a]	Machining[a]	Ease of Polishing[a]	High Temperature Properties[a]	Leakproof Properties[a]
	Sand Casting Alloy	Permanent Mold Casting Alloy	As Cast	Solution Heat Treatment	Precipitation Treatment	deg. Fahr.	deg. Cent.								
SAND AND PERMANENT MOLD															
No. 1	x	x	x			1175–1005	635–540	4	6	3	4	5	3	3	4
No. 2	x		x			1140–	615–	3	6	6	7	3	5	7	4
No. 3	x		x					3	6	6	7	3	5	7	4
No. 4	x	x	x			1175–1005	635–540	4	5	3	5	5	3	3	4
No. 5	x	x	x			1175–1005	635–540	4	5	3	4	5	3	3	4
No. 6	x		x			1160–1005	625–540	3	5	4	5	4	3	2	2
No. 7	x	x		x	x	1160–1004	625–540	3	5	3	4	4	3	2	5
No. 8	x			x	x	1195–1020	645–550	5	8	4	3	6	3	5	5
No. 10	x	x	x	x	x	1165– 995	630–535	5	6	4	4	4	3	2	6
No. 11	x	x	x			1165–1070	630–575	1	1	1	8	9	6	5	1
No. 12	x		x			1150–1070	620–575	1	1	1	8	9	6	3	2
No. 13	x		x			1185–1075	640–580	6	2	10	7	4	2	1	8
No. 14	x	x		x	x	1095–1000	590–540	1	1	2	8	9[b]	7	2	2
No. 15	x	x		x	x	1160–1075	625–580	1	1	1	8	7	6	3	1
No. 16	x			x	x	1130–1075	610–580	1	1	1	8	7	6	5	1
No. 17	x			x		1150– 840	620–450	6	2	10	7	2	4	1	8
DIE-CASTING ALLOYS															
No. 11						1165–1070	630–575	2	2	1	..	7	5	..	1
No. 12						1150–1070	620–575	1	1	2	..	8	5	..	1
No. 18						1165–1050	630–565	5	3	3	..	5	4	..	5
No. 19						1150–1025	620–550	3	3	4	..	4	4	..	3
No. 20						1200–1125	650–605	5	3	5	..	3	2	..	6
No. 21						1200–1100	650–595	4	4	5	..	2	2	..	4
No. 22						1150–1025	620–550	3	3	3	..	2	3	..	3

[a] Rated 1 for Excellent and 10 for Poor. Intermediate ratings are relative order of merit in each case and ba on only alloys listed. Die castings classified separately.

[b] With carboloy tools rated as 3.

TABLE XVI.—FOUNDRY CHARACTERISTICS OF MAGNESIUM CASTING ALLOYS.

Item	Type of Casting	Solidification Range		Fluidity (Order of Merit) 1 = Best	Shrinkage, in. per ft.[a]	Hot Shortne (Order Merit) 1 = Lea
		deg. Fahr.	deg. Cent.			
No. 1	Sand	1120–815	605–435	3	$\frac{3}{16}$	2
No. 2	Sand Permanent Die	1100–815	595–435	2	$\frac{3}{16}$	1
No. 3	Sand Permanent	1070–815	575–435	1	$\frac{3}{16}$	1
No. 4	Sand	1155–750	625–400	3	$\frac{3}{16}$	2
No. 5	Sand Permanent	1185–1050	640–565	4	$\frac{3}{16}$	3

[a] Use $\frac{5}{32}$ in. per ft. on large castings or where heavy cores prevent free shrinkage. For castings under 26 in. any one dimension, no changes are required in pattern equipment designed for aluminum alloys.

BIBLIOGRAPHY

1924

Jeffries, Zay., and Archer, R. S.

"The Science of Metals," McGraw-Hill Book Co., Inc., New York City (1924).

1926

Bengough, G. D., and Sutton, H.

"The Protection of Aluminum and Its Alloys Against Anodic Corrosion," *The Metal Industry* (London), Vol. 29, pp. 153, 175 (1926).

1927

"Light Metals and Alloys," National Bureau of Standards *Circular 346* (1927).

Painton, E. T.

"The Working of Aluminium," Chapman & Hall, London (1927).

Edwards, J. D.

"Aluminum Bronze Powder and Aluminum Paint," Chemical Catalogue Co., New York City (1927).

1928

Work, H. K.

"Electroplating on Aluminum and Its Alloys," *Transactions*, Am. Electrochemical Soc., Vol. 53, p. 361 (1928).

Player, E.

"The Production and Properties of Magnesium Alloy Castings," *Foundry Trade Journal*, Vol. 39, p. 473 (1928).

1930

Edwards, J. D., Frary, F. C., and Jeffries, Zay.

"The Aluminum Industry, Vol. II," McGraw-Hill Book Co., New York City (1930).

Harvey, W. G.

"Magnesium and Its Alloys in Aircraft," *Transactions*, Am. Electrochemical Soc., Vol. 56, p. 57 (1930).

Gann, J. A.

"The Magnesium Industry," *Industrial and Engineering Chemistry*, Vol. 22, p. 694 (1930).

Taylor, C. S., and Edwards, J. D.

"Physical Constants of Magnesium," *Transactions*, Am. Soc. Steel Treating, Vol. 17, p. 130 (1930).

1931

Anderson, R. J.

"Secondary Aluminum," Sherwood Press, Cleveland, Ohio (1931).

Work, H. K., and Slunder, C. J.

"Chromium Deposits Directly on Aluminum," *Transactions*, Am. Electrochemical Soc., Vol. 59, p. 429 (1931).

Work, H. K.

"Electroplating on Aluminum from Cyanide Solutions," *Transactions*, A
Electrochemical Soc., Vol. 60, p. 117 (1931).

Gann, J. A.

"Magnesium-Industry's Lightest Structural Metal," *Journal*, Soc. Au
motive Engrs., Vol. XXVIII, p. 653 (1931).

Templin, R. L., and Paul, D. A.

"The Mechanical Properties of Aluminum and Magnesium Alloys
Elevated Temperatures," Symposium on Effect of Temperature
the Properties of Metals, published jointly by the American Socie
for Testing Materials and The American Society of Mechanical En
neers, p. 198 (1931).

1932

Welty, G. D.

"Magnesium Alloys in Aircraft-Engine Construction," *Journal*, Soc. Au
motive Engrs., Vol. 30, p. 112 (1932).

Budgen, N. F.

"The Heat-Treatment and Annealing of Aluminium and Its Alloy
Chapman & Hall, London (1932).

Edwards, J. D., Tosterud, M., and Work, H. K.

"Oxide Coatings," *Electrical Engineering*, Vol. 51, p. 778 (1932).

1933

"National Metals Handbook," Am. Soc. Metals, Cleveland, Ohio (1933).

Budgen, N. F.

"Aluminium and Its Alloys," Pitman Press, London (1933).

"Alcoa Aluminum and Its Alloys," Aluminum Co. of America, Pittsburgh, P
(1933).

Edwards, J. D., and Wray, R. I.

"Painting Aluminum," *Industrial and Engineering Chemistry*, Vol. 2
January, 1933, p. 23.

1934

von Zeerleder, A.

"Technologie des Aluminium und seiner Legierungen," Akademisc
Verlag, G.m.b.h., Leipzig (1934).

Bengough, G. D., and Whitby, L.

"The Corrosion and Protection of Magnesium and Its Light Alloys
Transactions, Inst. Chemical Engrs., Vol. 11, p. 176 (1934).

Geschelin, Joseph.

"Wright Develops Technique for Production Casting of Magnesium All
Engine Parts," *Automotive Industry*, Vol. 70, p. 124 (1934).

"Dowmetal Databook," Dow Chemical Co., Midland, Mich. (1934).

REPORT OF COMMITTEE C-1
ON
CEMENT

The agitation in engineering and construction groups of the question of the need of various types of hydraulic cements and of the modification of the present standard portland cement for uses under different conditions has not been lost sight of by Committee C-1 on Cement. Indeed, it is doubtful if the membership has ever given more serious thought to the standards for cement than during the past year. This is particularly true of the producing members of the committee. As a result of this deep concern and earnest work, two new standards were presented at the March meeting of the committee—one covered a low heat of hardening cement and the other a cement to resist aggressive sulfate solutions, such as sea water or the white alkali salts abundant in some sections of the western part of the United States.

Although these elicited much discussion and were referred to the proper working committees for further studies, it would seem well to inform the public of the general nature of the requirements which were proposed for these cements and the general reactions of the membership of the committee towards them. Further, while these standards referred to special cements of the portland type, it would be well to remember that the committee is cognizant of the fact that very likely the same desired properties may be secured through the use of cements not wholly of this type or possibly of an entirely different type. Hence, a working committee has been collecting data regarding the nature of and the development here and abroad in the making, using, and past history of cements other than those made wholly from portland-cement clinker.

Cements developing relatively low amounts of heat during hardening are of much interest at the present time, due to their use in mass concrete; such as, the Pine Canyon Dam, Boulder Dam and Norris Dam. They are characterized by such a composition as to indicate by calculation low amounts of tricalcium aluminate and tricalcium silicate, high percentages of dicalcium silicate, and high percentages of tetracalcium ferro-aluminate if the producer chooses to reduce the total amount of silicates through the use of iron oxide as part of the raw mix. Such cements were made during the early part of the century; first, in Germany, where the Krupps produced t Erz-Zement, and in this country by the American Cement Co. Norfolk, Va., the Jamestown Cement Co. at Jamestown, Va., the Yankton Cement Co. at Yankton, S. D. At that time they w not suggested for the purposes now indicated, but were proposed eit for general use or if any particular use were stressed, it was tha SO_3 resistance.

As one would expect, low heat of reaction between the cem and the water is accompanied by low early strength. As measu by the standard tension briquet, the 7-day strength is about one-t less and the 28-day strength about one-fifth less than that develo by standard portland cement. The committee, however, is c sidering a compression specimen—a 2-in. plastic mortar cube an compressive strength of 500 and 1500 lb. per sq. in. at 7 and 28 d respectively. It has also been suggested that the desired quality low heat of hydration can be defined by a limit of 7 per cent u the tricalcium aluminate, and a further requirement that the sum the percentage of tricalcium silicate and twice the percentage tricalcium aluminate should not exceed 50 per cent. There are oth however, who feel that the specification should contain actual lin for the heat of hydration at 7 and 28 days, as determined by difference between the heat of solution of the unhydrated cement that hydrated for 7 and 28 days in a calorimeter. The fineness determined by the Wagner turbidimeter[1] has been proposed as less than 1500 sq. cm. per gram.

Low Heat Cement:

The Working Committee on Low Heat Cements, under direction of Mr. Ernest Ashton, has studied data available regard these cements, particularly those made available by the Bureau Reclamation and the Materials Testing Laboratory of the Univers of California. The greater part of these data have already b presented in the *Proceedings* of the American Concrete Institute[2] a of the American Society for Testing Materials[3] and hence are repeated here. The following abstract of the working committe report is presented below and indicates some thoughts which may of interest to the general public:

The committee meeting had much the character of an open hearing which all in attendance were called upon to ask questions and express opinio

---

[1] L. A. Wagner, "A Rapid Method for the Determination of the Specific Surface of Port Cement," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 553 (1933).

[2] *Proceedings*, Am. Concrete Inst., Vol. 4, Nos. 7, 8 and 9; Vol. 5, No. 1 (1933).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, pp. 484, 571 (1933).

The discussions were of such extreme interest that the subcommittee believes that a summary of a few of the subjects will be of interest to all members, and consequently is reporting the same as follows:

Attention was called to the difficulties on the part of some in making accurate tests for heat of hydration; others report such difficulties as being no more serious than those met with in performing other physical tests on cement.

The suggested specification of the Portland Cement Association which was recently distributed to members of Committee C-1 provides for limits of composition requirements instead of tests. Some hold to the view that a specification with test requirements is quite novel and that such a proposal should have the most searching investigation. It was believed that the committee should not balk at difficulties with tests but should make further studies to develop test methods which could be shown and accurately applied.

Some of those in attendance who have had extensive experience in the use of low heat cements called attention to the fact that experience with their use has not been all that was expected. It was pointed out that several other provisions for extraction of heat from large masses of concrete had to be provided in addition to the use of low heat cement; therefore, it was concluded that low heat cement is not a cure-all and prospective users should not look upon it as a means of eliminating cracks in structures.

One speaker emphasized the fact that concrete made with low heat cement in ordinary structures is just as likely to crack as concrete made with standard portlands.

Attention was called to the probability that conditions to be met on important large structures would vary, and the belief was that any one standard specification adopted at this time would not be likely to apply to various projects. It was also pointed out that the Federal Government is the principal user and has available all of the experience and research data on the subject.

The added costs and difficulties in manufacture, storage and distribution were cited and views were expressed by several that a standard specification, if adopted, would mislead cement users to specify this product for purposes for which it is not applicable.

The subcommittee in reporting these controversial points of view submits findings as follows:

The present demand for low heat cement exists entirely or nearly so in connection with large projects under various branches of the Federal Government.

That due to the incomplete character of the research, the inadequacy in the methods of test, that the several specification requirements must be subjected to further investigation and discussion.

That the work now going on, both in research and in use, furnishes the committee with a vast amount of data and experience which may be used as a guide for its further work.

The subcommittee therefore recommends that Committee C-1 refer to its various working committees this subject for further study and recommendation in accordance with its usual procedure, but it believes that, due to the wide divergence of views now existing among both users and manufacturers regarding proposed specifications, Committee C-1 should not adopt a standard specification for low heat cement until after such study and later recommendation.

Sulfate-Resisting Cement:

The sulfate-resisting portland cement standard under discus is particularly characterized by the use of a 2-in. plastic mortar specimen and suggested strengths of 1000 and 1800 lb. per sq. i 7 and 28 days, respectively, a limit of 8 per cent of tricalcium minate, and a specific surface of not less than 1500 sq. cm. per g No requirement other than the limit upon the amount of tricalc aluminate was proposed as a measure of the ability of the cemen resist the action of sulfate salt-containing waters. This detail caused considerable discussion. There are some who feel the indic amount of tricalcium aluminate is too high, at least for high centration of sulfates; others who think that if the resistance cement can be predicted by its chemical composition it can be as readily by placing a limit upon the ratio of alumina to iron as limit upon the calculated tricalcium aluminate; and others believe some type of specimen and test procedure should be devel which could be at least of the nature of a simulative or predi service test, such as the expansion of a lean mortar bar subjected t action of sodium sulfate (proposed by Thorvaldson) or the dis gration of set pastes of cement in solutions of sodium sulfate and accompanying cumulative amounts of sulfuric acid needed to mai the solutions at the same pH (proposed by Merriman).

Fineness:

The committee is indebted to its Working Committee on ness, under the chairmanship of Mr. J. C. Pearson, and a group cooperated with it, for some very interesting data obtained several devices for determining the sub-sieve gradation of particle and specific surface of a number of cements. The data and a discussion by the working committee are appended to this re The chairman feels that the committee is to be highly complime in its pioneering work on the particle size studies of sub-sieve parti While a knowledge of the true size of the particles comprising fini portland cement is of extreme value to those interested in this modity, the studies which have originated through the activiti Committee C-1 will be of great value to the many industries produ a finished product composed of finely divided particles. The Wa turbidimeter[1] which holds so much promise as an instrument cap of quickly and with great accuracy determining particle size distribution, is the outcome of the work, financially subsidize Committee C-1, of the Cement Reference Laboratory at the Nati

---

[1] *Loc. cit.*

Bureau of Standards. This instrument is the one used to determine the fineness of all cements so far purchased for Boulder Dam, and has also been placed in the specifications for the Wheeler and Norris Dams. At the time of preparing this report, 61 of these instruments have been ordered from one manufacturer alone. The data contained in the appended report show that there are other devices which can be used for determining the sub-sieve gradations and further indicate that, based upon certain assumptions, the results obtained by the variety of devices are in surprising accord when the lack of familiarity with these devices is borne in mind.

Plastic Mortar Tests:

The Working Committee on Plastic Mortar Tests, under the chairmanship of Mr. O. L. Moore, has been very active. It carried out a study in collaboration with a group of laboratories, the results of which are given in the report appended hereto. This is the latest of the series of studies which have extended over a period of years. The committee feels that now sufficient work has been done to warrant the Society issuing a tentative test method covering the various details of manipulation and equipment required to make and test a 2-in. plastic mortar cube. There is a strong feeling within the committee that the time is fast approaching, if not actually here, for incorporating such test piece in the standards for portland cement and the possible dropping from them of the tension briquet. In the meantime, this working committee has prepared the proposed Tentative Method of Test for Compressive Strength of Portland-Cement Mortars, appended hereto,[1] which is being recommended for publication by the Society as tentative.

Methods of Analysis:

The Working Committee on Methods of Analysis, under the chairmanship of Mr. W. C. Hanna, has largely completed a study of certain methods of making the chemical analyses of cements. It is hoped this study will result in the development of methods which would increase the average accuracy usually attained. This is needed at this time when the tendency to calculate compound compositions from the analyses is growing. Converting the percentage of oxides found by analyses into the several compounds assumed to be present in cement entails such calculations as will largely magnify any error in the analyses; hence, the need for indicating very definitely the details in analytical procedure which must be followed to insure the needed accuracy. While the committee cannot submit at the pres time a final report, it is rather certain that by the time of the n annual meeting tentative methods for rather complete analyses portland cement will be presented to the Society.

---

[1] See p. 743.—Ed.

Time of Set:

The Working Committee on Time of Setting, under the chairm ship of Mr. R. N. Young, and the Working Committee on Volu Change and Soundness of Portland Cement, under the chairmans of Mr. H. F. Gonnerman, have continued their studies during year. Neither have reports involving definite recommendations this time, but both groups will bear in mind the plastic mortar bei proposed for strength tests and direct their attention to the possibi of developing test methods which could be applied to mortars rat than continuing the use of the several pastes of neat cement. T latter working committee is concerned not only with the so-call soundness requirement but also with the volume change wh cements may undergo during the hardening, but which may not so great as to indicate unsoundness—warping, cracking, checki distortion, disintegration, etc. A brief interesting report by t committee on volume change is appended to this report.

Cement Reference Laboratory:

There is also appended hereto a report of the activities of t Cement Reference Laboratory. The completion of the third insp tion tour covering the entire country has made it possible to evalua the results of this work somewhat statistically. It is therefo interesting to note the tabulated information in the appended rep of the laboratory. These show very strikingly how after each insp tion there has been a decrease in the amount of apparatus found n conforming to the Society's standard. The report of the Workin Committee on Plastic Mortar Tests, appended hereto, also shows ho in recent years there has been a marked decrease in the widesprea results obtained by different laboratories in making the tension tes on samples of the same cement. Both of these facts are positi evidence of the work of the inspectors of the Reference Laboratory the laboratories which have been visited. The use of the specifi equipment and the instructions of inspectors as to how the te methods are to be carried out have brought about the uniformity practices which were so much desired, and have also brought about condition which permits a group of laboratories to make real com parative studies which correctly elucidate many problems.

Masonry Cement:

The sponsoring committee for the Tentative Specifications and Tests for Masonry Cement (C 91 – 32 T) has not been able to give this subject the attention it possibly deserves. Those engaged in making and testing this type of cement are not satisfied with the use of the flow table for determining consistency. It would seem that some modification in this method should be made. However, so far no one has offered such constructive criticisms as would merit opening up the question and the carrying out of an investigation. A Working Committee on Plasticity, under the chairmanship of Mr. H. D. Baylor, has a difficult task of the nature of the one confronting the Committee on Masonry Cement. Masonry cements are sold especially upon the argument that they are more workable or more plastic than other types of cements. A satisfactory method to measure this property is needed, but what development work has been done so far has not yielded the desired result. The Committee on Plasticity and the Committee on Masonry Cement would welcome suggestions in this matter, and would suggest this topic as an interesting field for research. Under the conditions which have existed, Committee C-1 requests the continuation of the Tentative Specifications and Tests for Masonry Cement (C 91 – 32 T) for another year.

High-Early-Strength Cement:

Last year the recommendation of Committee C-1 that its Tentative Specifications for High-Early-Strength Portland Cement (C 74 – 30 T) be adopted as standard was not acquiesced in by the membership on the floor at the 1933 annual meeting of the Society. The sponsoring committee having jurisdiction over this standard attempted by questionnaire to elicit the reasons for objections to the standard and the attitude of both the producing and consuming interests towards it. The analysis of the questionnaire was as much confusing as helpful. While there was a good consensus of opinion as to the majority of the requirements, on a few vital ones there was either a well balanced difference of opinion or a well developed and strong minority opinion. As a result, the sponsoring committee has been requested to further study the whole situation. During this study it is recommended that the present tentative specifications be continued for another year.

The Sponsoring Committee for Portland Cement, under the chairmanship of Mr. W. H. Klein, has been very active in the work dealing with low heat and sulfate-resisting cements. The results of these activities have been handed over to the respective working committees for further study. The committee has also given m attention to the present definition of portland cement. It also wi to acknowledge the possible ambiguity existing in Section 12 of present Standard Specifications for Portland Cement (C 9 – which reads as follows:

> Cement remaining in storage prior to shipment for a period greater 6 months after test shall be retested and shall be rejected if it fails to meet of the requirements of these specifications.

In later revisions of this standard the committee will suggest the phrase "after test" be replaced by a phrase reading "a completion of tests governing acceptance," meaning thereby a completion of the 7 or 28 day tests, whichever governs the accepta in any particular case.

The recommendation appearing in this report has been submi to letter ballot of the committee, which consists of 69 members, the following results:

Item	Affirmative	Negative	V
I. PROPOSED TENTATIVE STANDARD Method of Test for Compressive Strength of Portland Cement Mortars................	54	2	

The election of officers for the ensuing term of two y resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the commi which consists of 69 members; 60 members returned their ballots whom 57 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

P. H. BATES,
Chairma

G. A. SAEGER,
Secretary.

EDITORIAL NOTE

The proposed Tentative Method of Test for Compressive Strength Portland Cement Mortars, as modified on the floor of the annual meeting, Summary of Proceedings, page 23, was accepted for publication as tenta and appears on page 743.

REPORT ON COOPERATIVE SUB-SIEVE FINENESS TESTS BY THE WORKING COMMITTEE ON FINENESS

Recognition of the importance of fineness as a factor having a major influence on the properties of portland cement has led to the study and development of numerous schemes for determining the particle size distribution of cements, particularly in the region below the No. 325 sieve. One of the most important contributions to this development, from a practical viewpoint, was a paper by Mr. L. A. Wagner of the Cement Reference Laboratory of the National Bureau of Standards, published in the Society *Proceedings* of last year[1] in which a device was described whereby a practically complete particle size distribution of cement from the 7.5 to the 60 micron size could be obtained in about the length of time required for a single determination of the residue on a No. 200 sieve, as now required in the specifications for cement. Not only was this method shown to be rapid and dependable, but the instrument itself was made available at a reasonable price, and was procured by a number of laboratories in the latter part of 1933.

The time seemed favorable, therefore, for undertaking a series of cooperative fineness tests to determine particularly what order of agreement, and possibly of accuracy, might be expected from the various devices in use for sub-sieve particle size estimation. The task was undertaken by the Working Committee on Fineness, and during the past winter, results on four cements, prepared and issued by the Cement Reference Laboratory, have been obtained from 25 laboratories.

The time required for a complete study of these data was not available to the subcommittee to enable it to present a complete report in this annual report of Committee C-1, in lieu of which a brief summary of the tests is presented herewith, to be followed later by a more comprehensive report which will be distributed to members of Committee C-1 and to those outside the committee who participated in the tests.

Four portland cements covering a somewhat limited range in fineness, as well as variation in color, were furnished the cooperating laboratories. The cements used were designated Nos. 23678, 23679, 23680 and 23934. The approximate No. 200 and No. 325 sieve finenesses were supplied, and determination of fractions finer than 10, 20, 30 and 40 microns, respectively, were requested, with a

---

[1] L. A. Wagner, "A Rapid Method for the Determination of the Specific Surface of Portland Cement," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 553 (1933).

special request for determinations, by those who were in a posit
to make them, of fractions having smaller maximum sizes t
10 microns.

The response to the invitation to participate in these tests
more generous than had been anticipated. The returns included
following:

- 15 determinations with the Wagner turbidimeter;
- 8 determinations with the Reed-Lewis burette apparatus;
- 9 determinations with air analyzers of various types; and
- 4 determinations by various density methods.

The majority of the participants in these tests followed
instructions furnished with the particular apparatus used, but in vi
of the fact that all particle sizes were to be defined by Stokes l
that is, calculated from settling velocities, all operators were ur
to determine the fundamental constants of density and viscosity
the liquids employed, and to obtain, in so far as possible, independ
checks on the assumed separation sizes. Probably because of la
of experience in such work, or lack of suitable equipment, this calib
tion was not effectively carried out in the majority of the cooperat
laboratories.

The data of the tests are tabulated in Tables I to IV. T
tables need little explanation except in regard to the two meth
indicated for computing specific surface. The so-called commit
method was based on a computation of surface area for the seve
fractions beginning with the minus 10-micron fraction, having
assumed "surface mean diameter" of 5 microns, whereas the Wag
computation began with the minus 7.5-micron fraction, having
assumed surface mean diameter of 3.75 microns. It is this qu
arbitrary procedure that causes the Wagner value to be roug
200 sq. cm. per gram higher than that obtained by the commit
method.

Discussion of Results

In the brief discussion of results that is here possible, it shou
be stated that the working committee has not had opportunity
check the computations in the reports of the cooperating laboratori
and it is probable that some errors occur in the tabulated data th
will later be corrected. Due allowance must also be made for t
fact that in many cases the methods and apparatus were new
the operators, and as all the methods are more involved and requ
more exacting technique than the sieve tests of earlier years, it
felt that some of the rather wide variations in results may be fai
charged to lack of experience.

Table I.—Data on Cement No. 23678.

Laboratory	Method	Particle Size Distribution, Percentage Finer Than							Specific Surface, sq. cm. per gram	
		5 μ	7.5 μ	10 μ	20 μ	30 μ	40 μ	60 μ	Committee Method	Wagner Method
No. 1	Turbidimeter (Wagner)	....	23.1	27.5	46.1	61.6	74.4	88.0	1540	1760
No. 2	Turbidimeter (Wagner)	....	21.2	27.4	45.9	60.6	72.7	88.4	1537	1705
No. 4	Turbidimeter (Wagner)	....	25.4	30.5	46.2	62.5	72.2	88.0	1620	1830
No. 7	Turbidimeter (Wagner, modified)	....	20.5	27.5	48.0	63.0	75.8	90.0	1564	1728
No. 14	Turbidimeter (Wagner)	....	23.6	28.3	46.3	61.5	73.1	88.0	1564	1770
No. 16	Turbidimeter (Wagner)	....	22.6	29.3	47.6	63.9	75.2	88.2	1603	1787
No. 18	Turbidimeter (Wagner)	....	18.2	22.5	40.0	54.0	66.7	88.4	1275	1565
No. 18a	Turbidimeter (Univ. of Calif.)	....	....	....	....	....	....	....	1455	....
No. 19	Turbidimeter (Wagner)	....	21.3	28.1	46.6	63.3	75.0	87.9	1585	1680
No. 21	Turbidimeter (Wagner)	....	23.4	29.7	47.7	60.8	73.5	88.4	1607	1793
No. 22	Turbidimeter (Wagner)	....	21.4	28.6	44.8	64.9	76.4	87.7	1573	1787
No. 22a	Turbidimeter (Wagner)	....	15.6	23.6	41.8	54.1	66.9	87.6	1400	1474
No. 23	Turbidimeter (Wagner)	....	21.5	29.4	47.0	61.0	74.1	88.9	1604	1732
No. 24	Turbidimeter (Wagner)	....	27.2	32.0	48.3	62.3	74.0	87.7	1642	1950
No. 15	Turbidimeter (Wagner)	....	21.3	27.0	50.1	64.8	75.5	88.2	1558	1732
Avg. of Turbidimeter Values		....	21.9	27.9	46.1	61.3	73.3	....	1542	1735
Mean Percentage Deviation from Avg.		....	9.2	6.0	3.9	3.7	2.8	....	4.3	4.4
No. 8	Reed-Lewis Apparatus	....	....	29.5	42.6	61.0	72.2	(88)	1573	....
No. 9	Reed-Lewis Apparatus	....	....	25.8	41.6	60.9	72.1	(88)	1473	....
No. 10	Reed-Lewis Apparatus	....	....	27.3	40.5	59.4	71.5	(88)	1505	....
No. 11	Reed-Lewis Apparatus	....	....	28.6	46.3	63.4	73.5	(88)	1575	....
No. 12	Reed-Lewis Apparatus	....	....	29.2	43.0	61.5	72.5	(88)	1569	....
No. 13	Reed-Lewis Apparatus	....	....	29.0	43.8	60.5	72.0	(88)	1566	....
No. 22b	Reed-Lewis Apparatus	20.1	29.0	34.8	50.6	66.3	78.0	(88)	1768	2041
No. 25	Reed-Lewis Apparatus	....	....	26.2	42.1	62.2	73.0	88.3	1491	....
Avg. of Reed-Lewis Values.		20.1	29.0	28.8	43.8	61.9	73.1	....	1565	2041
Mean Percentage Deviation from Avg.		....	....	6.3	5.3	2.5	1.8	....	3.6	....
No. 2a	Analyzer (Portland Cement Assn.)	....	....	27.6	46.9	65.7	76.2	88.4	1563	....
No. 3	Analyzer (Smidth)	....	....	25.8	45.0	60.0	72.0	(88)	1488	....
No. 4a	Analyzer (Pearson)	....	....	27.8	48.4	66.5	82.6	(88)	1588	....
No. 14a	Analyzer (Pearson)	....	23.0	28.1	48.3	67.4	82.8	(88)	1597	1806
No. 15a	Analyzer (Smidth)	....	....	31.1	59.2	....	....	....	....	....
No. 17	Analyzer (Smidth)	....	....	....	48.2	66.8	75.6	(88)	....	....
No. 20	Analyzer (Roller)	11.5	18.7	23.8	40.2	56.6	68.7	84.6	1398	1553
No. 21a	Analyzer (Pearson)	....	....	26.8	47.9	65.4	75.4	(88)	1547	....
No. 23a	Analyzer (Portland Cement Assn.)	....	....	27.5	45.0	60.0	72.0	(88)	1533	....
Avg. of Analyzer Values		11.5	20.8	27.3	47.7	63.6	75.7	....	1531	1680
Mean Percentage Deviation from Avg.		....	....	5.1	6.3	5.5	4.8	....	3.3	....
No. 3a	Hydrometer (Bouyoukos)	18.0	23.0	27.4	46.3	61.0	69.8	83.2	1527	1744
No. 4b	Hydrometer (Lehigh Portland Cement Co.)	14.0	23.3	29.5	50.0	62.4	72.5	(88)	1616	1810
No. 5	Hydrometer (U. S. Bureau Public Roads)	16.2	28.5	38.0	55.5	72.2	80.8	(88)	1884	2098
No. 6	Microneter	14.0	22.0	30.0	51.0	66.0	77.0	89.0	1648	1797
Avg. of Density Values		15.5	24.2	31.2	50.7	65.4	75.0	....	1669	1862
Mean Percentage Deviation from Avg		9.9	8.9	10.8	5.0	5.7	5.2	....	6.4	6.3
Grand Average Values		15.6	22.5	28.4	46.5	62.5	74.0	....	1561	1769
Total Number of Tests		6	21	34	35	34	34	....	34	21

TABLE II.—DATA ON CEMENT NO. 23679.

Laboratory	Method	Particle Size Distribution, Percentage Finer Than							Specific Surfac sq. cm. per gra	
		5 μ	7.5 μ	10 μ	20 μ	30 μ	40 μ	60 μ	Committee Method	Wag Met
No. 1	Turbidimeter (Wagner)	....	26.4	31.4	49.8	63.6	73.6	88.0	1680	19
No. 2	Turbidimeter (Wagner)	....	24.6	30.9	48.8	62.8	73.4	88.3	1646	18
No. 4	Turbidimeter (Wagner)	....	29.1	34.3	49.4	62.2	72.0	87.4	1730	20
No. 7	Turbidimeter (Wagner, modified)	....	24.5	32.2	51.5	64.8	76.0	89.2	1702	19
No. 14	Turbidimeter (Wagner)	....	25.6	31.0	49.0	63.2	73.3	(87)	1641	18
No. 16	Turbidimeter (Wagner)	....	26.0	32.3	51.7	65.4	75.4	87.4	1695	19
No. 18	Turbidimeter (Wagner)	....	23.0	27.0	42.2	53.6	65.2	87.9	1482	16
No. 18a	Turbidimeter (Univ. of Calif.)	....	....	....	....	....	....	....	1625	..
No. 19	Turbidimeter (Wagner)	....	25.6	31.7	49.4	63.2	73.6	87.6	1671	19
No. 21	Turbidimeter (Wagner)	....	25.9	32.0	50.6	62.6	73.9	87.5	1683	19
No. 22	Turbidimeter (Wagner)	....	25.1	32.1	48.2	58.4	70.4	86.6	1647	18
No. 22a	Turbidimeter (Wagner)	....	21.2	28.0	44.2	58.0	70.2	86.6	1528	16
No. 23	Turbidimeter (Wagner)	....	25.6	32.2	48.8	61.2	72.1	87.2	1674	18
No. 24	Turbidimeter (Wagner)	....	28.1	33.1	47.1	60.9	73.2	87.1	1688	19
No. 15	Turbidimeter (Wagner)	....	24.0	30.8	49.7	65.4	76.0	87.3	1669	18
Avg. of Turbidimeter Values		....	25.3	31.4	48.6	61.8	72.6	....	1649	18
Mean Percentage Deviation from Avg		....	5.2	4.1	3.7	3.9	2.8	....	2.7	3
No. 8	Reed-Lewis Apparatus	....	....	32.2	45.6	62.4	72.9	(87)	1659	...
No. 9	Reed-Lewis Apparatus	....	....	29.3	44.2	62.5	72.5	(87)	1579	...
No. 10	Reed-Lewis Apparatus	....	....	30.4	43.9	61.9	72.4	(87)	1604	...
No. 11	Reed-Lewis Apparatus	....	....	30.2	46.0	63.5	73.0	(87)	1613	...
No. 12	Reed-Lewis Apparatus	....	....	31.7	44.9	62.4	72.4	(87)	1643	...
No. 13	Reed-Lewis Apparatus	....	....	30.7	46.5	62.6	72.5	(87)	1624	...
No. 22b	Reed-Lewis Apparatus	18.5	27.8	34.3	51.3	67.0	75.0	(87)	1745	20
No. 25	Reed-Lewis Apparatus	....	....	28.0	43.3	62.7	73.0	87.5	1543	...
Avg. of Reed-Lewis Values		18.5	27.8	30.8	45.7	63.1	73.0	....	1626	20
Mean Percentage Deviation from Avg		....	....	4.5	3.6	1.7	0.7	....	2.6	...
No. 2a	Analyzer (Portland Cement Assn.)	....	....	33.2	51.8	68.6	77.9	88.3	1738	...
No. 3	Analyzer (Smidth)	....	....	30.5	48.0	62.0	73.0	(87)	1628	...
No. 4a	Analyzer (Pearson)	....	....	29.8	52.2	69.0	84.3	(87)	1665	...
No. 14a	Analyzer (Pearson)	....	25.3	31.8	53.2	70.6	81.8	(87)	1715	19
No. 15a	Analyzer (Smidth)	....	....	36.5	60.8	....	....	....	....	...
No. 17	Analyzer (Smidth)	....	....	....	51.2	69.0	76.8	(87)	....	...
No. 20	Analyzer (Roller)	14.6	22.7	28.2	44.8	59.4	70.1	85.0	1540	17
No. 21a	Analyzer (Pearson)	....	....	29.3	51.9	67.8	76.2	(87)	1636	...
No. 23a	Analyzer (Portland Cement Assn.)	....	....	31.5	49.5	63.5	74.2	(87)	1666	...
Avg. of Analyzer Values		14.6	24.0	31.4	51.5	66.2	76.8	....	1655	18
Mean Percentage Deviation from Avg		....	....	6.1	5.4	5.2	4.4	....	2.5	...
No. 3a	Hydrometer (Bouyoukos)	14.9	20.6	25.6	48.0	62.2	70.2	81.4	1489	16
No. 4b	Hydrometer (Lehigh Portland Cement Co.)	16.7	26.0	32.7	52.4	66.9	76.8	(87)	1713	19
No. 5	Hydrometer (U. S. Bureau Public Roads)	19.8	36.0	44.0	59.8	72.2	80.8	(87)	2064	23
No. 6	Microneter	17.0	25.5	33.0	54.0	67.5	78.0	89.0	1744	19
Avg. of Density Values		17.1	27.0	33.8	53.5	67.2	76.4	....	1752	19
Mean Percentage Deviation from Avg.		7.9	16.6	15.0	6.3	3.9	4.1	....	8.9	10.
Grand Average Values		16.9	25.6	31.6	49.3	63.8	74.3	....	1657	19
Total Number of Tests		6	21	34	35	34	34	....	34	21

TABLE III.—DATA ON CEMENT NO. 23680.

Laboratory	Method	Particle Size Distribution, Percentage Finer Than							Specific Surface, sq. cm. per gram	
		5 μ	7.5 μ	10 μ	20 μ	30 μ	40 μ	60 μ	Committee Method	Wagner Method
No. 1	Turbidimeter (Wagner)	....	28.6	34.0	55.1	70.3	81.8	94.9	1800	2100
No. 2	Turbidimeter (Wagner)	....	29.4	36.5	55.2	73.9	85.0	95.4	1877	2165
No. 4	Turbidimeter (Wagner)	....	32.7	38.8	57.1	73.4	82.4	94.8	1937	2245
No. 7	Turbidimeter (Wagner, modified)	....	27.0	35.0	56.0	71.3	82.8	94.3	1830	2072
No. 14	Turbidimeter (Wagner)	....	29.6	36.2	56.0	72.7	84.6	(95)	1869	2136
No. 16	Turbidimeter (Wagner)	....	28.6	35.4	55.2	72.8	84.9	95.2	1839	2126
No. 18	Turbidimeter (Wagner)	....	30.1	34.5	56.9	71.0	82.0	94.6	1825	2080
No. 18a	Turbidimeter (Univ. of Calif.)	....	....	....	....	....	....	....	1820	....
No. 19	Turbidimeter (Wagner)	....	27.9	34.9	54.4	72.4	84.2	94.7	1827	2089
No. 21	Turbidimeter (Wagner)	....	28.5	35.3	56.5	71.8	84.1	95.4	1847	2112
No. 22	Turbidimeter (Wagner)	....	28.0	35.7	54.7	69.0	80.3	94.3	1828	2086
No. 22a	Turbidimeter (Wagner)	....	18.9	26.6	44.6	61.3	76.8	94.3	1527	1692
No. 23	Turbidimeter (Wagner)	....	31.2	38.2	57.2	71.7	82.8	95.7	1924	2210
No. 24	Turbidimeter (Wagner)	....	34.5	41.7	60.9	74.9	87.2	100.	2051	2410
No. 15	Turbidimeter (Wagner)	....	29.2	35.3	56.2	73.6	84.5	95.2	1850	2126
Avg. of Turbidimeter Values		....	28.9	35.6	55.5	71.5	83.1	....	1843	2119
Mean Percentage Deviation from Avg		....	7.2	5.5	3.4	2.8	2.2	....	3.3	3.7
No. 8	Reed-Lewis Apparatus	....	....	36.8	51.3	70.7	81.0	(95)	1851	....
No. 9	Reed-Lewis Apparatus	....	....	31.7	49.3	69.9	80.7	(95)	1708	....
No. 10	Reed-Lewis Apparatus	....	....	34.1	48.5	68.8	79.8	(95)	1761	....
No. 11	Reed-Lewis Apparatus	....	....	34.1	51.3	71.3	81.1	(95)	1788	....
No. 12	Reed-Lewis Apparatus	....	....	35.9	51.0	70.3	80.9	(95)	1824	....
No. 13	Reed-Lewis Apparatus	....	....	36.1	53.1	70.6	81.0	(95)	1841	....
No. 22b	Reed-Lewis Apparatus	25.6	33.0	38.1	54.2	71.2	80.5	(95)	1889	2221
No. 25	Reed-Lewis Apparatus	....	....	35.6	50.7	70.2	80.5	95.0	1814	....
Avg. of Reed-Lewis Values		25.6	33.0	35.3	51.2	70.4	80.7	....	1809	2221
Mean Percentage Deviation from Avg		....	....	4.2	2.5	0.8	0.4	....	2.4	....
No. 2a	Analyzer (Portland Cement Assn.)	....	....	36.3	57.4	75.8	86.2	95.2	1887	....
No. 3	Analyzer (Smidth)	....	....	34.0	54.0	70.8	82.5	(95)	1795	....
No. 4a	Analyzer (Pearson)	....	....	33.8	58.6	77.1	91.2	(95)	1841	....
No. 14a	Analyzer (Pearson)	....	27.6	36.2	59.0	77.8	89.4	(95)	1903	2122
No. 15a	Analyzer (Smidth)	....	....	42.5	71.7	....	....	....	....	....
No. 17	Analyzer (Smidth)	....	....	....	52.7	76.8	84.1	(95)	....	....
No. 20	Analyzer (Roller)	16.3	24.7	30.7	50.6	67.0	79.2	90.2	1674	1889
No. 21a	Analyzer (Pearson)	....	....	32.7	58.5	76.4	84.9	(95)	1801	....
No. 23a	Analyzer (Portland Cement Assn.)	....	....	34.8	55.7	69.9	82.3	(95)	1823	....
Avg. of Analyzer Values		16.3	26.2	35.1	57.6	74.0	85.0	....	1818	2006
Mean Percentage Deviation from Avg.		....	....	6.8	6.8	4.8	3.5	....	2.9	....
No. 3a	Hydrometer (Bouyoukos)	22.0	28.0	34.8	54.2	68.4	78.9	90.5	1797	2052
No. 4b	Hydrometer (Lehigh Portland Cement Co.)	19.0	29.5	37.1	58.8	74.8	85.7	(95)	1915	2170
No. 5	Hydrometer (U. S. Bureau Public Roads)	22.2	39.5	46.0	68.5	82.5	91.5	(95)	2237	2614
No. 6	Microneter	18.5	29.0	38.0	62.0	78.0	87.0	94.5	1972	2181
Avg. of Density Values		20.4	31.5	39.2	60.9	75.9	85.8	....	1980	2254
Mean Percentage Deviation from Avg.		8.3	12.7	9.9	7.2	5.8	4.1	....	6.5	8.0
Grand Average Values		20.6	29.3	35.8	55.6	72.3	83.2	....	1848	2140
Total Number of Tests		6	21	34	35	34	34	....	34	21

TABLE IV.—DATA ON CEMENT NO. 23934.

Laboratory	Method	Particle Size Distribution, Percentage Finer Than							Specific Sur sq. cm. per	
		5 μ	7.5 μ	10 μ	20 μ	30 μ	40 μ	60 μ	Committee Method	W M
No. 1	Turbidimeter (Wagner)	....	27.8	33.4	53.4	66.4	76.6	89.8	1750	
No. 2	Turbidimeter (Wagner)	....	27.0	33.3	51.5	65.3	75.4	90.3	1735	
No. 4	Turbidimeter (Wagner)	....	30.4	35.6	54.3	67.2	77.0	88.4	1809	
No. 7	Turbidimeter (Wagner, modified)	....	23.0	30.0	50.0	64.3	76.7	90.3	1642	
No. 14	Turbidimeter (Wagner)	....	27.7	33.3	53.0	66.4	76.3	(89.5)	1743	
No. 16	Turbidimeter (Wagner)	....	26.4	33.7	52.2	67.4	77.4	89.2	1714	
No. 18	Turbidimeter (Wagner)	....	25.7	28.7	48.1	61.6	72.5	89.9	1578	
No. 18a	Turbidimeter (Univ. of Calif.)	....	....	....	....	....	....	....	1640	
No. 19	Turbidimeter (Wagner)	....	27.1	32.7	51.5	66.0	77.1	89.3	1722	
No. 21	Turbidimeter (Wagner)	....	25.6	32.6	50.3	63.9	75.1	90.2	1708	
No. 22	Turbidimeter (Wagner)	....	27.0	36.6	50.1	64.5	75.2	88.7	1791	
No. 22a	Turbidimeter (Wagner)	....	23.5	30.6	47.2	61.5	72.0	88.7	1623	
No. 23	Turbidimeter (Wagner)	....	28.2	35.8	52.4	65.0	75.9	90.2	1801	
No. 24	Turbidimeter (Wagner)	....	31.8	37.4	53.2	69.7	79.3	89.0	1860	
No. 15	Turbidimeter (Wagner)	....	25.9	31.6	53.7	67.7	78.3	89.2	1716	
Avg. of Turbidimeter Values		....	26.9	33.2	51.5	65.5	76.0	....	1723	
Mean Percentage Deviation from Avg		....	6.1	5.7	3.1	2.7	1.9	....	3.4	
No. 8	Reed-Lewis Apparatus	....	....	32.6	46.2	62.9	73.8	(89.5)	1681	
No. 9	Reed-Lewis Apparatus	....	....	32.7	46.0	63.5	74.2	(89.5)	1687	
No. 10	Reed-Lewis Apparatus	....	....	30.4	43.3	61.7	73.2	(89.5)	1607	
No. 11	Reed-Lewis Apparatus	....	....	32.8	46.6	65.1	75.1	(89.5)	1695	
No. 12	Reed-Lewis Apparatus	....	....	33.0	46.2	64.3	74.9	(89.5)	1695	
No. 13	Reed-Lewis Apparatus	....	....	33.0	47.9	64.5	75.0	(89.5)	1702	
No. 22b	Reed-Lewis Apparatus	24.1	30.2	34.5	48.6	63.6	73.0	(89.5)	1736	
No. 25	Reed-Lewis Apparatus	....	....	33.5	46.3	64.0	74.9	90.2	1707	
Avg. of Reed-Lewis Values		24.1	30.2	32.8	46.4	63.7	74.3	....	1689	
Mean Percentage Deviation from Avg		....	....	2.1	2.1	1.2	1.0	....	1.3	
No. 2a	Analyzer (Portland Cement Assn.)	....	....	34.1	51.2	68.4	78.6	90.3	1764	
No. 3	Analyzer (Smidth)	....	....	30.0	46.8	62.5	75.0	(89.5)	1619	
No. 4a	Analyzer (Pearson)	....	....	30.5	51.8	68.3	82.7	(89.5)	1680	
No. 14a	Analyzer (Pearson)	....	23.8	30.9	52.1	69.2	81.5	(89.5)	1693	
No. 15a	Analyzer (Smidth)	....	....	35.7	61.1	....	....	....	....	
No. 17	Analyzer (Smidth)	....	....	....	52.4	68.8	77.2	(89.5)	....	
No. 20	Analyzer (Roller)	14.4	22.1	27.6	45.8	60.3	70.9	86.5	1536	
No. 21a	Analyzer (Pearson)	....	....	27.8	51.4	68.1	77.3	(89.5)	1602	
No. 23a	Analyzer (Portland Cement Assn.)	....	....	32.0	49.0	62.8	74.0	(89.5)	1681	
Avg. of Analyzer Values		14.4	23.0	31.1	51.3	66.0	77.2	....	1654	
Mean Percentage Deviation from Avg		....	....	6.9	5.3	4.8	3.7	....	3.5	
No. 3a	Hydrometer (Bouyoukos)	17.8	23.0	30.0	48.9	60.9	69.9	83.0	1605	
No. 4b	Hydrometer (Lehigh Portland Cement Co.)	15.2	25.9	33.7	52.5	66.3	76.1	(89.5)	1749	
No. 5	Hydrometer (U. S. Bureau Public Roads)	19.2	34.0	41.5	59.5	73.5	82.2	(89.5)	2013	
No. 6	Microneter	17.5	25.5	33.0	53.5	68.0	79.0	90.0	1747	
Avg. of Density Values		17.4	27.1	34.6	53.6	67.2	76.8	....	1778	
Mean Percentage Deviation from Avg		6.5	12.7	10.1	5.5	5.3	4.9	....	6.6	
Grand Average Values		18.0	26.8	32.8	50.5	65.4	76.0	....	1709	
Total Number of Tests		6	21	34	35	34	34	....	34	

Looking first at the group averages, it is seen that the averages of the turbidimeter values are very close to the grand average values. The uniformity of results in the group, as indicated by the mean deviations, is also comparatively good, but the deviations are rather large in the two finer fractions. As might be expected, also, the deviations in specific surface as computed by the Wagner method tend to be slightly larger than those computed by the committee method.

The values obtained with the Reed-Lewis apparatus show the smallest average deviations, which is probably due mainly to the fact that the users of this device were for the most part well-trained and experienced in its operation. The method is quite empirical, however, and the apparatus must be calibrated by the use of a sample of known particle size distribution.

The air-analyzer results are interesting in showing that this very different type of mechanical analysis gives results which are in good agreement with the grand average values, although the deviations are rather large, as might be expected from the variety of devices used. The density methods are too new (with the exception of the micronometer) and too undeveloped at this time to indicate what may be expected of them. The hydrometer methods show some promise and have the advantage of requiring very small outlay for equipment and of being particularly adapted to a study of the distribution in the finer range of particle sizes. Further investigation of these methods seems desirable.

The committee offers only two conclusions at this time:

First, that all of the methods used in these cooperative tests seem to be capable of giving the desired particle size distribution of cement to at least 20 microns, and most of them to 10 microns, when the apparatus is properly calibrated. There are of course great differences in the time and effort involved in the several methods.

Second, that the expression of fineness in terms of specific surface is an arbitrary procedure which must be defined by some instrument, or by some prescribed method of calculation. With any given instrument or method, the determination of specific surface at the present time is sufficiently uncertain to need a fairly large tolerance. The data of these tests suggest that such tolerance should not be less than 5 per cent.

Respectfully submitted,

J. C. Pearson, *Chairman.*
For Working Committee on Fineness.

REPORT OF WORKING COMMITTEE ON PLASTIC MORTAR TESTS FOR PORTLAND CEMENT

REPORT ON COOPERATIVE TESTS OF TWELVE CEMENTS BY TEN LABORATORIE

INTRODUCTION

In 1928, E. M. Brickett, in a paper before the Society,[1] report
compressive strength results of 2-in. cubes made of plastic mort
composed of 1:2.75 by weight of cement and local graded sand a
having a consistency maintained constant by means of a flow tab
Since the publication of this paper, Committee C-1 has made seve
investigations of this type of test, at first employing a fixed consisten
and later a fixed water-cement ratio and graded sand of pure silica fro
Ottawa, Ill. The latter method, because of the elimination of erro
well known to accompany the measurement of consistency and corre
tions for absorption of sands, resulted in considerable improvement
the uniformity of the cube results. The standard tension tests ma
for comparison in these investigations also showed improvement
uniformity from time to time and always were a little better in so
respects than the cube test results, although the latter afforded a bett
means of evaluating the compressive strength of concrete. The pro
ress made, however, was so encouraging that Committee C-1 decid
to make further studies based on the experience obtained from pre
ous investigations and embodying further refinement of methods.

Late in December, 1932, an outline of the cooperative tests w
prepared and submitted to members of the working committee a
others and to officials of Committee C-1 for suggestions and criticism
In March, 1933, the outline was approved and the tests started.

PURPOSE AND SCOPE OF INVESTIGATION

The purpose of the investigation was to determine (*a*) wheth
further refinements in methods would result in improved uniformi
of compressive strength results of plastic mortar cubes, (*b*) the rel
tions existing between standard tension, concrete and plastic mort
strength results, (*c*) the merits of standard Ottawa sand and grad
Ottawa sand for plastic mortar tests, (*d*) to obtain data on which
base possible specification requirements, (*e*) to determine the effe
of rate of loading on compressive strength of cubes, and (*f*) to secu

---

[1] E. M. Brickett, "A Plastic Mortar Compression Test for Cement," *Proceedings*, Am. Soc. Te
ing Mats., Vol. 28, Part II, p. 432 (1928).

voids-cement ratio (V/C) data for study as a possible further refinement in plastic mortar tests.

The tests were made by ten laboratories using seven brands of normal portland cement and five brands of high-early-strength cement, chosen to represent the range of test results ordinarily encountered in these two types of cement. Each cooperating laboratory made parallel series of standard tension briquets, 2-in. cubes of graded Ottawa sand and 2-in. cubes of standard Ottawa sand, three test specimens for each type of test for ages of 1, 3, 7 and 28 days on each cement, and repeated the tests on four days. Two laboratories included 3 by 6-in. concrete cylinders. In addition, each laboratory made supplementary tests, four obtained rate of loading data of their screw-type machines and one made an additional study on the effect upon strength results of cubes of three uniform rates of loading on a hydraulic machine. The investigation comprised the making of about 11,745 2-in. cubes, 5760 briquets, 800 concrete cylinders and 1300 miscellaneous tests, a total of about 19,605 tests. In addition about 14,500 cube dimensions were measured and load-time data recorded on the testing of about 2000 cubes.

MATERIALS

The cements were donated by the following manufacturers:

Alpha Portland Cement Co., Easton, Pa.
Ash Grove Lime and Portland Cement Co., Kansas City, Mo.
Glens Falls Portland Cement Co., Glens Falls, N. Y.
Hawkeye Portland Cement Co., Des Moines, Iowa
Huron Portland Cement Co., Detroit, Mich.
Lehigh Portland Cement Co., Allentown, Pa.
Lone Star Cement Co., Indiana, Inc., Greencastle, Ind.
Marquette Cement Manufacturing Co., Chicago, Ill.
Medusa Portland Cement Co., Cleveland, Ohio
The Monarch Cement Co., Humboldt, Kans.
North American Cement Corp., Albany, N. Y.
West Penn Cement Co., Butler, Pa.

The cements and the graded Ottawa sand were shipped to the laboratory of the Portland Cement Association where each lot was mixed, apportioned and expressed to the cooperating laboratories, the sand in bags and the cements in sealed tin containers. As the subcommittee had no funds, the cost of the graded Ottawa sand and the expense of preparing and distributing the materials were borne by the Portland Cement Association. The sand grading was 95 per cent retained on the No. 100 sieve, 72 per cent on the No. 50, 5 per cent on the No. 30, and none on the No. 16 sieve. The cooperating laboratories furnished the standard Ottawa sand.

COOPERATING LABORATORIES

The following laboratories cooperated in the investigation:

NAME	ADDRESS	INDIVIDUAL
Ash Grove Lime and Portland Cement Co.	Chanute, Kans.	G. O. Gardne
The Bessemer Cement Corp.	Youngstown, Ohio	R. E. Roscoe
U. S. Bureau of Public Roads	Washington, D. C.	E. F. Kelley
National Bureau of Standards	Washington, D. C.	P. H. Bates
Illinois State Division of Highways	Springfield, Ill.	V. L. Glover
Lehigh Portland Cement Co.	Allentown, Pa.	J. C. Pearson
Lone Star Cement Company of New York, Inc.	Hudson, N. Y.	M. A. Swayze
Missouri State Highway Department	Jefferson City, Mo.	F. V. Reagel
Portland Cement Association	Chicago, Ill.	H. F. Gonner
Universal Atlas Cement Co.	Chicago, Ill.	O. L. Moore

METHODS OF TEST

Tension Tests.—Tensile strength tests were made in accorda with the Standard Methods of Sampling and Testing Portland ment (A.S.T.M. Designation: C 77 – 32) of the American Society Testing Materials.[1]

Compression Tests—Plastic Mortar Cubes.—A fixed water-cem ratio (W/C) of 0.80 was used in two series of tests, one with gra Ottawa sand, 1:2.75 by weight, and one with standard Ottawa sa 1:3 by weight. The mixing of the mortar was done in a granite w bowl of about 1-gal. capacity by vigorous and continuous stirr squeezing and kneading with one hand protected by a snug-fitt rubber glove. The total quantity of mixing water was placed in bowl, which had previously been wiped with a damp cloth, the t amount of cement added to the water and the two ingredients mi for 30 seconds. Then about one-half of the sand was added and mixing continued for another 30 seconds. The remaining sand then added and the mixing of the entire batch continued for minute. Immediately following the completion of the mixing, molds were filled about one-half full with the mortar and the mor lightly puddled with the finger tips, protected with snug-fitting rub gloves or finger cots. Then the molds were filled with the mortar a the operation of puddling with the finger tips repeated. The cu were smoothed off with a trowel immediately in such a manner t the surfaces of the cubes were slightly (about $\frac{1}{64}$ in.) above the of the mold and then placed in the moist closet. The cube molds w made water-tight by means of a mixture of paraffin and resin (3 pa paraffin to 5 parts resin by weight), heated to a temperature of 230

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 6.

260 F., (110 to 125 C.) and brushed around the outer edges of the molds where they come in contact with the base plates.

The load was applied to the faces of the cube which were in contact with the sides of the mold. The testing was done in six laboratories on screw-type machines and in four laboratories on hydraulic machines. An initial load of 1000 lb., applied at a relatively rapid rate, was used for both types of machine, after which the specimen was loaded continuously to failure at a uniform rate of 3000 lb. per sq. in. per minute in the case of the hydraulic machines and with the slowest speed in the case of the screw-type machines.

Unless otherwise specified, all test procedures, temperatures, humidities, storage of test specimens, etc., were in accordance with the Standard Methods of Sampling and Testing Portland Cement (A.S.T.M. Designation: C 77 – 32) of the American Society for Testing Materials.[1]

The method of measuring the pressure in molding the briquets and the several types of testing machines used in the tests are shown in the following table:

Laboratory	Method of Measuring Pressure in Molding Briquets	Machines Used in Testing				
		Tension Tests (Briquets)		Compression Tests (2-in. Cubes)		
		Capacity, lb.	Type	Capacity, lb.	Type	Idling Rate, in. per minute
No. 1	Practiced on platform scale	1000	Riehle	200 000	Hydraulic (Olsen)	....
No. 2	Delimeter	1000	Olsen	30 000	Hydraulic (Olsen)	....
No. 3	Judgment of operator	1000	Riehle	40 000	Screw (Olsen)	0.050
No. 4	Delimeter	1000	Fairbanks	300 000	Hydraulic	....
No. 5	Practiced on platform scale	1000	Olsen-Boyd	60 000	Screw (Riehle)	0.042
No. 6	Delimeter	1000	Riehle	50 000	Screw (Riehle)	0.055
No. 7	Delimeter	1000	Olsen	60 000	Hydraulic (Southwark-Emery)	....
No. 8	Delimeter	1000	Riehle	100 000	Screw (Riehle)	0.05
No. 9	Judgment of operator	1000	Olsen	50 000	Screw (Riehle)	0.05
No. 10	Delimeter	1000	Olsen	50 000[a] 200 000	Screw (Riehle) Screw (Olsen)	0.053 0.040

[a] About 45 per cent of the cubes were tested on a 200,000-lb. machine while the 50,000-lb. machine was being repaired.

Compression Tests—Concrete.—Because of economic conditions, tests of concrete were not requested in the outline of cooperative tests but two of the laboratories included concrete tests using a water-cement ratio (*W/C*) of 1.00, 3 by 6-in. cylinders, 0 to $\frac{3}{4}$-in. aggregate and employing the methods used in their customary practice. The aggregates used were washed and screened sand and gravel from Elgin, Ill., for Laboratory No. 9 and from Plainfield, Ill., for Laboratory No. 10. The cylinders were stored in the molding room, covered with steel capping plates, for the first 24 hr. by Laboratory No. 9 and in a moist closet by Laboratory No. 10, after which they were stored in a fog

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 6.

TABLE I.—TENSILE STRENGTHS OF STANDARD TENSION BRIQUETS AND COMPRESSIVE STRENGTHS OF PLASTIC MORTAR 2-IN. CUBES, GRADED OTTAWA SAND AND STANDARD OTTAWA SAND.

Graded Ottawa sand cubes: 1:2.75 by weight; water-cement ratio, 0.8.
Standard Ottawa sand cubes: 1:3 by weight; water-cement ratio, 0.8.
Each value is average of twelve test specimens, three made on each of four different days.

Laboratory	1-Day			3-Days			7-Days			28-Days		
	Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.	
		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand
CEMENT NO. 1												
No. 1	153	389	273	260	1208	883	324	2029	1623	400	3506	2946
No. 2	118	518	422	239	1218	1029	330	1906	1547	415	3427	2756
No. 3	171	611	490	269	1247	1013	328	1944	1572	404	3214	2816
No. 4	144	506	362	251	1354	861	340	2154	1644	430	3676	3124
No. 5	126	422	342	254	1149	978	346	1999	1602	405	3432	3267
No. 6	131	475	374	237	1302	972	309	2274	1759	407	3840	3530
No. 7	152	524	479	243	1300	1065	310	2183	1716	400	3998	3306
No. 8	153	555	489	274	1344	1059	335	1978	1617	414	3344	3121
No. 9	150	436	306	257	1212	857	329	2008	1466	427	3632	3013
No. 10	138	501	372	263	1235	960	328	2185	1820	404	3735	3340
Average	144	494	391	255	1257	968	328	2066	1637	411	3580	3122
Percentage mean variation	8.5	10.2	16.2	3.9	4.3	6.4	2.5	5.1	4.8	2.1	5.5	6.1
CEMENT NO. 2												
No. 1	131	437	281	251	1531	1269	346	3235	2694	455	5325	4646
No. 2	103	582	425	244	1441	1178	368	2779	2421	488	5382	4575
No. 3	149	616	467	282	1675	1329	365	3099	2620	459	4953	4639
No. 4	119	529	353	262	1491	1053	355	3065	2303	458	5166	4135
No. 5	125	413	351	263	1240	1093	369	2555	2303	481	4639	4398
No. 6	114	468	353	242	1530	1135	348	3350	2589	430	6115	5358
No. 7	137	508	497	264	1542	1344	361	3073	2725	446	5332	4866
No. 8	135	555	485	290	1545	1305	385	2986	2599	469	5072	4554
No. 9	133	443	325	268	1522	1146	364	3005	2352	465	5115	4713
No. 10	128	459	352	273	1541	1187	361	3097	2612	431	5197	4505

TABLE I.—(*Continued*).

Graded Ottawa sand cubes: 1:2.75 by weight; water-cement ratio, 0.8.
Standard Ottawa sand cubes: 1:3 by weight; water-cement ratio, 0.8.
Each value is average of twelve test specimens, three made on each of four different days.

Laboratory	1-Day			3-Days			7-Days			28-Days		
	Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.	
		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand
CEMENT No. 3												
No. 1	237	866	621	343	2248	1727	386	3342	2592	471	5210	4327
No. 2	209	950	746	324	2139	1640	378	3214	2676	479	4972	4301
No. 3	261	1113	869	339	2076	1716	397	3113	2544	448	4926	4171
No. 4	220	948	734	350	2324	1814	422	3364	2637	485	4851	4026
No. 5	249	861	667	345	1882	1736	401	3172	2493	494	4864	4142
No. 6	216	910	704	332	2261	1792	387	3749	2898	453	6060	5286
No. 7	229	973	783	320	2292	1720	382	3529	2669	460	5412	4515
No. 8	241	1014	848	354	2276	1815	395	3243	2692	484	5199	4469
No. 9	239	893	622	350	2214	1699	408	3352	2524	493	5290	4288
No. 10	235	970	722	334	2272	1744	380	3540	2812	440	5201	4453
Average	234	950	732	339	2198	1740	394	3362	2654	471	5198	4398
Percentage mean variation	5.1	5.7	8.8	2.7	4.5	2.3	2.8	4.4	3.6	3.5	4.5	5.1
CEMENT No. 4												
No. 1	155	350	227	263	1231	856	345	2292	1814	447	4342	3690
No. 2	131	497	376	229	1221	932	314	2210	1936	440	4137	3594
No. 3	142	536	406	227	1202	895	329	2250	1798	427	4246	3683
No. 4	149	511	350	249	1331	920	344	2211	1687	453	3992	3277
No. 5	143	478	352	245	1218	903	337	2187	1689	443	4121	3372
No. 6	132	486	355	233	1352	975	320	2405	1887	433	4832	4173
No. 7	143	495	409	239	1274	941	321	2408	1837	416	4521	3731
No. 8	165	573	440	281	1360	989	365	2391	1923	471	4430	3668
No. 9	129	434	310	232	1290	859	325	2308	1643	419	4459	3469
No. 10	161	556	399	265	1408	1016	353	2536	1931	432	4518	3615
Average	145	492	362	246	1289	929	335	2320	1814	438	4360	3627
Percentage mean variation	6.9	8.9	12.0	5.9	4.6	4.5	4.0	4.0	4.9	2.9	4.4	4.5

TABLE I.—(*Continued*).

Graded Ottawa sand cubes: 1:2.75 by weight; water-cement ratio, 0.8.
Standard Ottawa sand cubes: 1:3 by weight; water-cement ratio, 0.8.
Each value is average of twelve test specimens, three made on each of four different days.

Laboratory	1-Day			3-Days			7-Days			28-Days		
	Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.	
		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand
CEMENT NO. 5												
No. 1	136	279	177	260	1313	1092	340	2942	2437	400	4616	4385
No. 2	121	446	318	255	1329	1073	354	2677	2325	457	4556	4212
No. 3	143	502	381	258	1445	1209	346	2764	2390	400	4434	4227
No. 4	122	414	281	265	1487	1089	346	2880	2270	432	4567	3974
No. 5	127	389	310	257	1362	1175	344	2459	2258	423	4232	4121
No. 6	104	395	299	242	1456	1166	324	2990	2679	405	5263	5203
No. 7	129	357	321	249	1370	1195	340	2783	2519	391	4825	4467
No. 8	137	435	335	273	1364	1246	352	2759	2457	399	4634	4377
No. 9	130	356	253	261	1395	1124	332	2752	2301	420	4553	4068
No. 10	129	414	315	256	1473	1193	324	2909	2507	391	4605	4175
Average	128	399	299	258	1399	1156	340	2791	2414	412	4628	4321
Percentage mean variation	5.8	10.9	12.4	2.2	3.7	4.3	2.4	4.0	4.4	4.1	3.6	5.3
CEMENT NO. 6												
No. 1	137	325	233	255	1487	1085	375	3142	2644	450	5387	4646
No. 2	124	457	342	257	1417	1076	380	2916	2420	466	5299	4549
No. 3	143	554	417	264	1536	1170	366	2945	2474	457	5106	4635
No. 4	120	461	335	261	1713	1256	358	3175	2499	464	5471	4508
No. 5	127	508	381	247	1392	1118	343	2907	2394	441	4800	4632
No. 6	101	425	330	236	1525	1153	333	3046	2821	431	5929	5528
No. 7	120	426	345	243	1465	1127	333	3029	2502	435	5421	4796
No. 8	124	511	379	268	1364	1140	382	3003	2488	472	5177	4762
No. 9	127	435	315	257	1533	1139	367	3105	2549	440	5471	4603
No. 10	131	478	354	276	1618	1216	356	3211	2647	427	5502	4686
Average	125	458	343	256	1505	1148	359	3048	2544	448	5356	4734
Percentage mean variation	6.1	9.7	9.4	3.5	5.3	3.5	4.1	2.9	3.8	3.0	3.9	3.7

TABLE I.—(*Continued*).

Graded Ottawa sand cubes: 1:2.75 by weight; water-cement ratio, 0.8.
Standard Ottawa sand cubes: 1:3 by weight; water-cement ratio, 0.8.
Each value is average of twelve test specimens, three made on each of four different days.

Laboratory	1-Day			3-Days			7-Days			28-Days		
	Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.	
		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand
CEMENT No. 7												
No. 1	151	327	216	265	1465	998	331	2506	2025	421	4221	3537
No. 2	154	448	349	272	1480	1179	322	2547	2067	414	4066	3511
No. 3	169	565	469	272	1600	1286	322	2600	2156	416	4225	3509
No. 4	141	384	282	287	1620	1175	333	2561	1860	424	4023	3177
No. 5	134	524	401	248	1408	1106	326	2452	2010	414	3973	3572
No. 6	141	448	330	250	1440	1251	309	2772	2168	397	4491	4147
No. 7	145	492	414	264	1535	1269	322	2627	2143	402	4381	3685
No. 8	175	577	451	287	1683	1308	344	2814	2226	441	4482	3812
No. 9	143	419	272	261	1438	1080	332	2342	1814	421	4051	3212
No. 10	150	524	385	279	1623	1272	342	2764	2107	418	4517	3672
Average	150	471	357	268	1529	1192	328	2598	2058	417	4243	3583
Percentage mean variation	6.3	13.9	18.8	4.1	5.4	7.1	2.5	4.5	5.1	2.0	4.2	5.5
CEMENT No. 8												
No. 1	300	1227	912	432	3412	2792	487	5215	4302	548	6314	5767
No. 2	295	1274	1060	427	3147	2702	482	4533	3779	523	6212	5245
No. 3	302	1612	1316	407	3648	3099	443	4952	4326	503	6521	5687
No. 4	268	1305	950	398	3510	2726	446	4639	3886	530	6216	5071
No. 5	317	1474	1187	408	3214	2763	490	4451	4007	528	5665	5267
No. 6	272	1284	1125	393	3247	3057	461	5013	4713	516	7173	6631
No. 7	279	1393	1219	397	3564	2954	452	5231	4256	504	6668	5687
No. 8	309	1452	1216	435	3619	3024	487	5105	4337	571	6742	5889
No. 9	281	1290	1040	396	3390	2796	438	4850	4095	511	6452	5592
No. 10	296	1482	1163	409	3641	2943	475	5030	4124	506	6622	5663
Average	292	1379	1119	410	3439	2886	466	4902	4182	524	6458	5650
Percentage mean variation	4.6	7.5	9.2	3.1	4.6	4.5	3.9	4.6	4.9	3.1	4.4	5.0

TABLE I.—(*Continued*).

Graded Ottawa sand cubes: 1:2.75 by weight; water-cement ratio, 0.8.
Standard Ottawa sand cubes: 1:3 by weight; water-cement ratio, 0.8.
Each value is average of twelve test specimens, three made on each of four different days.

Laboratory	1-Day			3-Days			7-Days			28-Days		
	Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.	
		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand
CEMENT No. 9												
No. 1	284	1429	1150	390	3292	2779	457	5010	4308	521	6533	5833
No. 2	271	1484	1209	380	3490	2622	436	4741	3910	518	6517	5206
No. 3	297	1809	1524	360	3414	3005	440	4936	4530	500	6502	5872
No. 4	285	1450	1132	382	3259	2615	451	4868	3771	494	6098	5296
No. 5	275	1570	1370	383	3039	2713	456	4262	4035	507	5744	5341
No. 6	266	1369	1131	386	3207	2917	449	5214	4620	504	7171	6703
No. 7	277	1487	1320	375	3348	2773	442	4998	4110	481	6444	5652
No. 8	282	1636	1359	397	3488	2916	478	5072	4480	516	6717	5822
No. 9	273	1456	1073	389	3187	2615	470	4817	4030	512	6499	5641
No. 10	287	1609	1234	372	3521	2687	448	5023	4002	485	6473	5520
Average	280	1530	1250	381	3324	2764	453	4894	4180	504	6470	5689
Percentage mean variation	2.6	6.6	9.2	2.0	3.8	4.1	2.2	3.6	5.8	2.2	3.5	5.2
CEMENT No. 10												
No. 1	323	1446	1163	435	3925	3352	478	5048	4527	525	6450	5650
No. 2	301	1521	1319	434	3729	3082	495	5203	4183	546	6347	5489
No. 3	311	2081	1815	388	4157	3556	447	5400	4721	498	6472	5653
No. 4	295	1344	1146	397	3850	3105	471	5117	4310	509	6615	5237
No. 5	322	1802	1557	409	3714	3261	460	4939	4185	498	5611	5341
No. 6	301	1398	1157	412	3854	3396	469	5547	4906	514	7507	6645
No. 7	301	1398	1329	396	3883	3252	436	5289	4375	486	6748	5685
No. 8	304	1791	1512	408	4105	3402	468	5546	4743	518	6920	5834
No. 9	312	1493	1152	399	3911	3262	472	5117	4141	497	6446	5459
No. 10	322	1699	1392	390	4062	3429	438	5230	4382	466	6414	5475
Average	309	1597	1354	407	3919	3310	463	5244	4447	506	6553	5647
Percentage mean variation	2.8	12.3	12.7	3.1	2.9	3.5	3.1	3.1	5.0	3.3	4.8	4.4

TABLE I.—(*Continued*).

Graded Ottawa sand cubes: 1:2.75 by weight; water-cement ratio, 0.8.
Standard Ottawa sand cubes: 1:3 by weight; water-cement ratio, 0.8.
Each value is average of twelve test specimens, three made on each of four different days.

Laboratory	1-Day			3-Days			7-Days			28-Days		
	Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.		Tensile Strength (Briquets), lb. per sq. in.	Compressive Strength (2-in. Cubes), lb. per sq. in.	
		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand
CEMENT No. 11												
No. 1	298	1348	944	422	3439	2604	459	4535	3548	484	5550	4573
No. 2	297	1467	1126	389	3354	2363	433	4415	3490	451	5408	4470
No. 3	295	1706	1288	378	3255	2649	427	4288	3353	454	5269	4266
No. 4	252	1336	960	349	2924	2160	415	3928	3129	442	5158	3925
No. 5	302	1668	1233	395	3235	2543	438	3979	3415	498	4716	4513
No. 6	255	1289	1029	376	3235	2671	430	4639	3910	454	6006	5285
No. 7	266	1468	1152	375	3273	2444	399	4279	3325	440	5387	4223
No. 8	296	1583	1277	395	3538	2783	449	4786	3918	464	6007	5050
No. 9	281	1315	864	374	3133	2251	449	4111	3207	452	5218	4041
No. 10	305	1532	1137	373	3529	2707	407	4632	3555	439	5324	4474
Average	289	1471	1101	383	3291	2517	431	4359	3485	458	5404	4482
Percentage mean variation	5.6	8.2	11.0	3.7	4.2	6.8	3.5	5.6	5.7	3.2	5.0	6.7
CEMENT No. 12												
No. 1	334	1104	860	451	4229	3425	488	5942	5160	530	6598	5944
No. 2	311	1281	1048	447	3750	3182	492	5592	4653	536	6431	5811
No. 3	335	1601	1307	416	4090	3362	467	5488	4700	487	6495	5604
No. 4	283	1141	841	415	4056	3036	479	5799	4432	497	6525	5627
No. 5	311	1668	1300	410	3896	3315	486	5238	4484	490	5836	5019
No. 6	275	1206	924	408	4265	3713	473	6428	5728	507	7995	7418
No. 7	310	1321	1112	409	4173	3377	467	5952	4733	469	7025	5856
No. 8	320	1353	1211	438	4175	3419	490	5857	4948	506	7110	6050
No. 9	290	1176	875	401	4108	3391	460	5718	4403	495	6837	5902
No. 10	329	1383	1034	431	4221	3444	470	5903	4686	489	6753	5837
Average	310	1323	1051	423	4096	3366	477	5792	4793	501	6760	5907
Percentage mean variation	5.2	10.7	13.8	3.6	2.9	3.4	2.0	3.9	6.1	3.1	5.7	5.7

TABLE II.—PERCENTAGE MEAN VARIATIONS OF THE TENSILE AND COMPRESSIVE STRENGTHS OBTAINED BY EACH LABORATORY FROM THE AVERAGE STRENGTH (TABLE I) OBTAINED BY THE TEN LABORATORIES.

Each test repeated four times.

Cement	1-Day			3-Days			7-Days			28-Days		
	Briquets	Cubes		Briquets	Cubes		Briquets	Cubes		Briquets	Cubes	
		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand
No. 1	8.5	10.2	16.2	3.9	4.3	6.4	2.5	5.1	4.8	2.1	5.5	6.1
No. 2	7.7	11.4	16.3	4.3	4.6	7.2	2.2	5.1	5.6	3.1	4.7	4.4
No. 3	5.1	5.7	8.8	2.7	4.5	2.3	2.8	4.4	3.6	3.5	4.5	5.1
No. 4	6.9	8.9	12.0	5.9	4.6	4.5	4.0	4.0	4.9	2.9	4.4	4.5
No. 5	5.8	10.9	12.4	2.2	3.7	4.3	2.4	4.0	4.4	4.1	3.6	5.3
No. 6	6.1	9.7	9.4	3.5	5.3	3.5	4.1	2.9	3.8	3.0	3.9	3.7
No. 7	6.3	13.9	18.8	4.1	5.4	7.1	2.5	4.5	5.1	2.0	4.2	5.5
No. 8	4.6	7.5	9.2	3.1	4.6	4.5	3.9	4.6	4.9	3.1	4.4	5.0
No. 9	2.6	6.6	9.2	2.0	3.8	4.1	2.2	3.6	5.8	2.2	3.5	5.2
No. 10	2.8	12.3	12.7	3.1	2.9	3.5	3.1	3.1	5.0	3.3	4.8	4.4
No. 11	5.6	8.2	11.0	3.7	4.2	6.8	3.5	5.6	5.7	3.2	5.0	6.7
No. 12	5.2	10.7	13.8	3.6	2.9	3.4	2.0	3.9	6.1	3.1	5.7	5.7
Average	5.6	9.7	12.5	3.5	4.2	4.8	2.9	4.2	5.0	3.0	4.5	5.1
High	8.5	13.9	18.8	5.9	5.4	7.2	4.1	5.6	6.1	4.1	5.7	6.7
Low	2.6	5.7	8.8	2.0	2.9	2.3	2.0	2.9	3.6	2.0	3.5	3.7

room by Laboratory No. 9 and in water tanks by Laboratory No. 10. A water-cement ratio (W/C) of 1.00 was specified inasmuch as it was expected that the voids-cement ratio (V/C) (expressed in the same terms as W/C) of the plastic mortar would be in the neighborhood of 1.00, which would place the plastic mortar and concrete on about the same V/C basis since the concrete would be expected to have a V/C of about 1.00.

Supplementary Tests.—Flow tests were made on the plastic mortar using 10-in. flow tables and thirty $\frac{1}{8}$-in. drops in about 15 seconds. The unit weight of mortar was determined by weighing the mortar content in a measure having a capacity of one liter or less. In filling the molds for each of these tests the mortar was puddled with the finger tips in the same manner as in molding the cube test specimens. The unit weight of concrete was determined by weighing the contents of a $\frac{1}{10}$-cu. ft. measure.

DISCUSSION OF TESTS

Uniformity in Strength Between Laboratories.—In Table I are summarized the strength data in pounds per square inch of the briquets and the cubes for each laboratory and each cement, each value representing the average of 12 test specimens, 3 made daily. The table also gives the percentage mean variations of the strength results between the ten laboratories, which values are tabulated in Table II. Strength results of all test specimens, whether manifestly faulty or not, were included in the averages and in the calculations of the percentage mean variations. In general, the laboratories check among themselves very much better in the briquet test than in the cube tests and the graded Ottawa sand mortar cubes have a good advantage as to uniformity over the standard Ottawa sand mortar cubes. The grand average percentage mean variations for briquets is 3.8 per cent, for graded Ottawa sand cubes 5.7 per cent, and for standard Ottawa sand cubes 6.9 per cent. If the 1-day values, which are always the highest, are not considered, the above figures become 3.1, 4.3 and 5.0 per cent, respectively. As will be pointed out later in the discussion of the data grouped in other tables, there is reason to believe that these values for cubes can be reduced considerably in future tests. In the comparison of this series with previous series using plastic mortars and standard tension tests it is interesting to note that each succeeding series of tests shows considerable improvement as to uniformity, not only in the cube test but in the briquet test as well. It is also of interest to note that the cube tests of the present series are more uniform than the briquet tests of the 1929 and the 1930 series.[1] The following table makes this comparison:

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 266 (1929); also Vol. 30, Part I, p. 437 (1930).

Specimen	Test Series	Number of Laboratories	Percentage Mean Variations in Strength Results				
			1-Day	3-Day	7-Day	28-Day	Average
Briquets	1929 Report	7	10.4[a]	7.3[b]	6.5	6.1	7.6
	1930 Report	10	11.3	5.5	4.5	4.0	6.3
	Present Series	10	5.6	3.5	2.9	3.0	3.8
Cubes, Graded Ottawa Sand	1929 Report	7	14.6[a]	10.1[b]	11.3	9.1	11.3
	1930 Report	10	10.1	7.9	7.1	8.3	8.4
	Present Series	10	9.7	4.2	4.2	4.5	5.7
Cubes, Standard Ottawa Sand	Present Series	10	12.5	4.8	5.0	5.1	6.9

[a] 2-Day. [b] 4-Day.

Table III gives the strength results in pounds per square inch from each laboratory grouped as to the normal portland cements and the high-early-strength cements, together with the percentage mean variations between the laboratories. Each value is the average strength of all cements in a group tested on four days. The percentage mean variations again show that the laboratories are able to obtain a little better uniformity with the briquet than with the cube and that the graded Ottawa sand cube is a little better than the standard Ottawa sand cube.

Hydraulic and Screw-Type Testing Machines.—The compressive strengths obtained by the four laboratories using hydraulic machines are about the same as those obtained by the six laboratories using the screw-type machines but the uniformity is considerably better for the laboratories using the hydraulic machines as is indicated by the following table:

	Compression Tests (2-in. Cubes, Graded Ottawa Sand)[a]				Compression Tests (2-in. Cubes, Standard Ottawa Sand)[b]			
	1-day	3-days	7-days	28-days	1-day	3-days	7-days	28-days
AVERAGES FOR 7 NORMAL PORTLAND CEMENTS								
Average Results on 4 Hydraulic Machines, lb. per sq. in.	514	1529	2742	4645	391	1173	2222	3973
Percentage Mean Variation, 4 Hydraulic Machines	8.7	3.2	2.5	2.2	13.7	2.7	2.6	3.4
Average Results on 6 Screw-Type Machines, lb. per sq. in.	553	1524	2746	4663	423	1203	2243	4118
Percentage Mean Variation, 6 Screw-Type Machines	8.6	3.4	4.1	4.6	11.3	3.3	4.5	5.1
AVERAGES FOR 5 HIGH-EARLY-STRENGTH CEMENTS								
Average Results on 4 Hydraulic Machines, lb. per sq. in.	1361	3580	5017	6262	1097	2867	4109	5312
Percentage Mean Variation, 4 Hydraulic Machines	3.5	2.0	2.6	1.7	8.3	3.8	3.8	3.3
Average Results on 6 Screw-Type Machines, lb. per sq. in.	1526	3637	5052	6374	1227	3036	4289	5550
Percentage Mean Variation, 6 Screw-Type Machines	8.7	3.5	4.3	5.9	11.2	3.2	5.6	7.0

[a] Mortar, 1:2.75 by weight; water-cement ratio, 0.8.
[b] Mortar, 1:3 by weight; water-cement ratio, 0.8.

TABLE III.—TENSILE STRENGTHS OF STANDARD BRIQUETS AND COMPRESSIVE STRENGTHS OF PLASTIC MORTAR CUBES.

Each value is average of tests made on four days and on several cements.

Laboratory	Tensile Strength (Briquets), lb. per sq. in.				Compressive Strength (2-in. Cubes, Graded Ottawa Sand),[a] lb. per sq. in.				Compressive Strength (2-in. Cubes, Standard Ottawa Sand),[b] lb. per sq. in.			
	1-day	3-days	7-days	28-days	1-day	3-days	7-days	28-days	1-day	3-days	7-days	28-days
AVERAGE STRENGTH RESULTS OF 7 NORMAL PORTLAND CEMENTS												
No. 1	157	271	349	435	425	1497	2784	4658	290	1130	2261	4025
No. 2	137	260	349	451	557	1463	2607	4548	425	1158	2199	3928
No. 3	168	273	350	430	642	1540	2673	4443	500	1231	2222	3954
No. 4	145	275	357	449	536	1617	2773	4535	385	1167	2128	3746
No. 5	147	265	352	443	513	1379	2533	4294	400	1158	2107	3929
No. 6	134	253	333	422	515	1552	2941	5218	392	1206	2400	4746
No. 7	151	260	338	421	539	1540	2804	4841	464	1237	2301	4195
No. 8	161	289	365	450	603	1562	2739	4620	489	1266	2286	4109
No. 9	150	269	351	441	488	1515	2696	4653	343	1129	2093	3909
No. 10	153	278	349	420	557	1596	2892	4753	414	1227	2348	4064
Average	150	269	349	436	537	1526	2744	4656	410	1191	2234	4060
Percentage mean variation	5.1	2.9	1.6	2.4	7.8	3.3	3.4	3.6	11.7	3.6	3.8	4.3
AVERAGE STRENGTH RESULTS OF 5 HIGH-EARLY-STRENGTH CEMENTS												
No. 1	308	426	474	522	1311	3659	5150	6289	1006	2990	4369	5553
No. 2	295	415	468	515	1405	3494	4897	6183	1152	2790	4003	5244
No. 3	308	390	445	488	1762	3713	5013	6252	1450	3134	4326	5216
No. 4	277	388	452	494	1315	3520	4870	6122	1006	2728	3906	5031
No. 5	305	401	466	504	1636	3420	4574	5514	1329	2919	4025	5096
No. 6	274	395	456	499	1309	3562	5368	7170	1073	3151	4775	6536
No. 7	287	390	439	476	1413	3648	5150	6454	1226	2960	4160	5421
No. 8	302	415	474	515	1563	3785	5273	6699	1315	3109	4485	5729
No. 9	287	392	458	493	1346	3546	4923	6290	1001	2863	3975	5327
No. 10	308	395	448	477	1541	3795	5164	6317	1192	3042	4150	5394
Average	295	401	458	498	1460	3614	5038	6329	1175	2969	4217	5455
Percentage mean variation	3.8	2.7	2.2	2.5	9.1	2.9	3.6	4.2	10.8	3.9	5.1	5.3

[a] Mortar, 1:2.75 by weight; water-cement ratio 0.8.

[b] Mortar, 1:3 by weight; water-cement ratio 0.8.

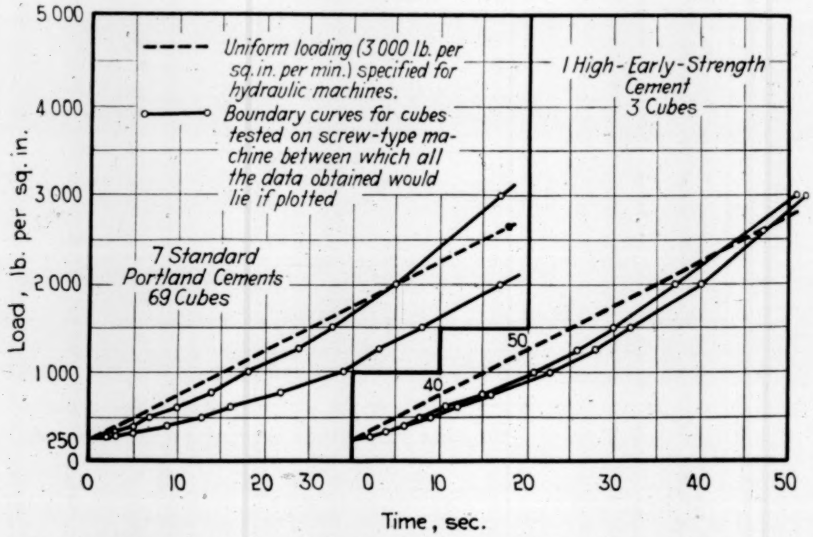


FIG. 1.—Load-Time Curves, 28-day Plastic Mortar Cubes of Graded Ottawa Sand. Results from Laboratory No. 5.

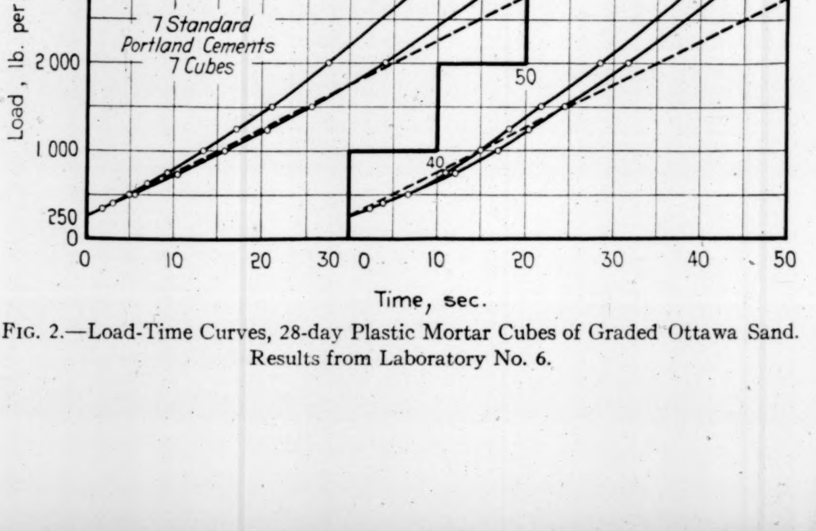


FIG. 2.—Load-Time Curves, 28-day Plastic Mortar Cubes of Graded Ottawa Sand. Results from Laboratory No. 6.

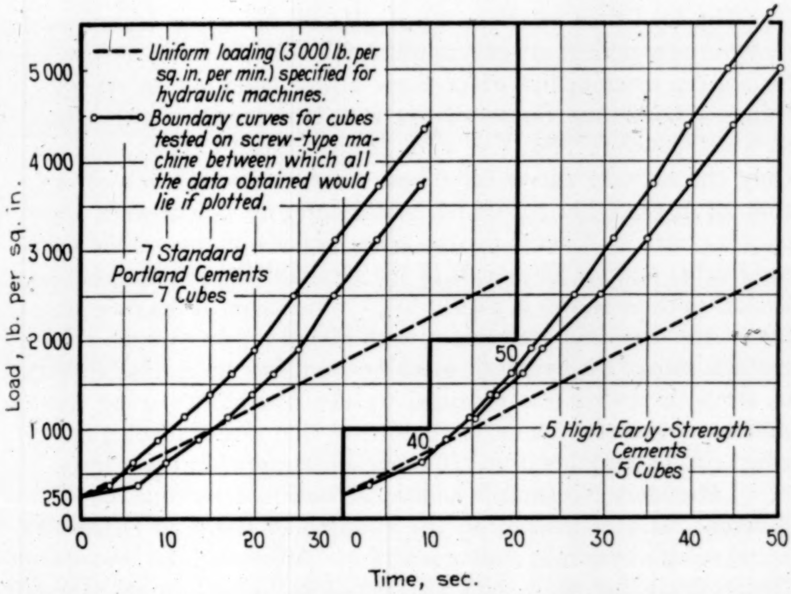


FIG. 3.—Load-Time Curves, 28-day Plastic Mortar Cubes of Graded Ottawa Sand. Results from Laboratory No. 8.

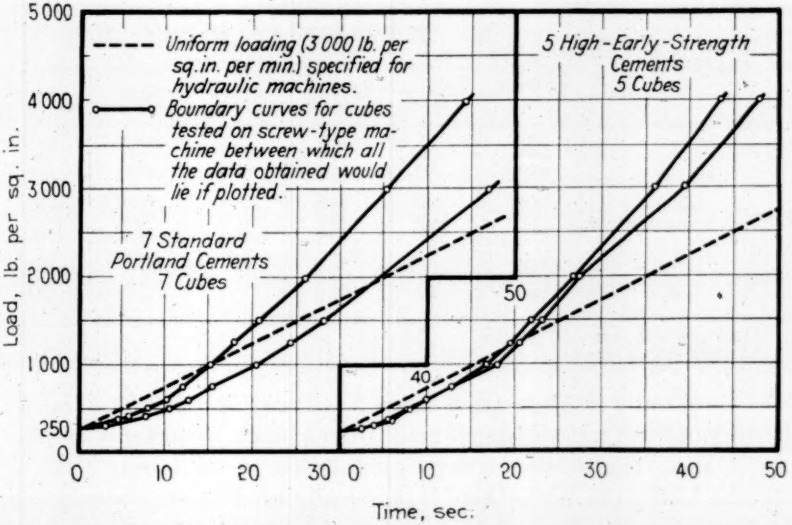


FIG. 4.—Load-Time Curves, 28-day Plastic Mortar Cubes of Graded Ottawa Sand. Results from Laboratory No. 9.

The load-time relations when plotted for cubes tested on the screw-type machines are curves which fall within a fairly narrow band for a given machine but which cover a wide band for the several machines. Load-time curves of the four laboratories which obtained data are shown in Figs. 1 to 4 for 28-day graded Ottawa sand cubes. Only the extreme curves have been charted for each laboratory, so that all of the other curves for that laboratory fall between the two curves plotted. Curves for the other periods of the graded Ottawa sand cubes and for all periods of the standard Ottawa sand cubes are similar to those shown in Figs. 1 to 4. Since most of the rates of loading of the screw-type machines were higher on an average than the uniform rate of the hydraulic machines and since no marked difference in strength results was obtained by the laboratories using the two different types of machine, it would seem that rate of loading has little effect upon strength within the range encountered in these tests.

Laboratory No. 4 made additional tests to determine the effect of different rates of loading on the strength of standard Ottawa sand cubes using a hydraulic testing machine. After an initial load of about 300 to 500 lb. per sq. in. had been imposed, the uniform rates of loading were carefully maintained until failure. The results summarized in the following table indicate that a range in rate of loading from 1000 to 6000 lb. per sq. in. per minute has very little effect upon the strength results:

Age of Cube	Loading Rate, lb. per sq. in. per minute	Compressive Strength (2-in. Cubes, Standard Ottawa Sand, lb. per sq. in.)[a]				
		Cement No. 2	Cement No. 6	Cement No. 8	Cement No. 9	Cement No. 23806[b]
3 Days	1000	1120	1100	2600	2510	1060
	3000	1080	1070	2600	2500	1080
	6000	1120	1120	2860	2400	1040
7 Days	1000	2120	2170	3620	3810	1800
	3000	2200	2190	3870	3700	1870
	6000	2180	2260	3840	3700	1900
28 Days	1000	....	....	....	....	2910
	3000	....	....	....	....	2950
	6000	....	....	....	....	2990

[a] Each value is an average of 6 to 9 cubes.
[b] A normal portland cement.

Uniformity in Strengths of Three Specimens in a Batch.—The uniformity of three test specimens made from a batch of mortar is shown in Table IV. The cubes are very much better in uniformity than the standard briquets, while there is practically no difference between the two types of mortar cubes. The grand average percentage mean variation for briquets is 3.8 per cent, for graded Ottawa sand cubes

TABLE IV.—PERCENTAGE MEAN VARIATIONS IN TENSILE AND COMPRESSIVE STRENGTHS OF THREE TEST SPECIMENS FROM THEIR AVERAGE.

Each value is average percentage mean variation of four tests made on four days and on several cements.

Laboratory	1-Day			3-Days			7-Days			28-Days		
	Briquets	Cubes		Briquets	Cubes		Briquets	Cubes		Briquets	Cubes	
		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand
AVERAGES OF 7 NORMAL PORTLAND CEMENTS												
No. 1	4.3	3.6	3.0	4.0	2.1	2.9	4.1	1.8	3.0	3.5	2.2	2.8
No. 2	3.5	2.5	3.6	3.3	2.0	2.1	3.3	2.2	2.8	3.5	2.6	2.1
No. 3	3.7	2.9	2.5	2.6	2.3	2.3	3.3	2.2	2.2	3.3	2.3	3.1
No. 4	3.7	1.5	2.6	4.2	2.1	2.7	4.5	1.8	2.6	3.6	2.2	2.0
No. 5	5.7	2.4	2.7	4.1	3.0	2.9	3.2	3.1	2.9	2.5	4.0	3.7
No. 6	5.2	2.8	2.0	3.2	2.6	2.3	3.4	2.8	2.3	3.9	1.8	1.9
No. 7	4.4	2.5	2.6	4.4	2.2	2.3	4.0	2.3	2.0	4.4	2.1	2.5
No. 8	4.5	2.4	3.3	4.9	2.5	1.8	3.1	2.3	2.1	3.9	2.5	2.5
No. 9	4.0	1.9	2.2	4.7	2.6	2.7	4.5	2.2	2.3	3.5	2.9	3.7
No. 10	3.5	2.4	2.9	3.7	2.4	3.8	4.5	2.7	3.5	3.8	3.0	3.1
Average	4.2	2.5	2.7	3.9	2.4	2.6	3.8	2.3	2.6	3.6	2.6	2.7
AVERAGES OF 5 HIGH-EARLY-STRENGTH CEMENTS												
No. 1	4.9	2.1	2.1	4.2	2.1	2.2	3.7	3.2	2.0	3.7	2.1	2.4
No. 2	2.5	2.2	1.9	3.2	2.5	3.0	3.4	1.8	2.7	3.6	2.0	1.9
No. 3	3.8	1.6	1.7	3.7	3.1	2.6	3.9	2.6	2.5	3.5	2.2	2.9
No. 4	3.1	1.7	1.7	4.8	2.0	2.1	3.2	3.1	2.0	3.7	2.4	3.0
No. 5	3.1	2.9	1.8	3.4	3.6	2.9	2.4	4.3	3.1	2.6	5.3	4.3
No. 6	3.3	1.6	1.7	3.1	1.5	1.5	3.0	1.6	1.6	2.8	1.4	1.4
No. 7	3.9	1.5	2.0	3.9	2.2	2.3	3.4	1.9	1.8	3.2	1.9	2.0
No. 8	4.5	1.8	1.8	4.1	1.8	2.0	3.7	2.6	2.5	3.3	2.2	2.5
No. 9	4.5	1.3	2.3	3.9	2.2	2.8	5.0	2.2	3.3	3.9	3.0	3.0
No. 10	4.2	3.0	2.8	3.9	2.6	2.7	3.8	3.2	2.9	3.9	3.7	3.5
Average	3.8	2.0	2.0	3.8	2.4	2.4	3.5	2.6	2.4	3.4	2.6	2.7

TABLE V.—PERCENTAGE MEAN VARIATIONS IN TENSILE AND COMPRESSIVE STRENGTHS OF FOUR TESTS FROM THEIR AVERAGE. TESTS MADE ON SEVERAL CEMENTS AND ON FOUR DAYS.

Laboratory	1-Day			3-Days			7-Days			28-Days		
	Briquets	Cubes		Briquets	Cubes		Briquets	Cubes		Briquets	Cubes	
		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand		Graded Ottawa Sand	Standard Ottawa Sand
AVERAGES OF 7 NORMAL PORTLAND CEMENTS												
No. 1	4.3	8.0	9.4	4.1	4.5	5.0	3.4	4.0	4.8	4.2	4.5	3.8
No. 2	3.3	4.7	5.3	2.4	1.8	3.4	2.7	2.7	3.4	2.2	2.1	1.8
No. 3	3.5	3.0	3.4	2.2	3.9	2.8	2.5	3.1	2.9	2.6	3.5	3.8
No. 4	3.7	4.1	5.1	2.9	4.8	6.9	3.6	4.5	6.4	3.7	4.9	3.8
No. 5	4.0	4.4	3.9	3.5	6.2	5.0	2.5	4.1	4.5	2.5	2.8	3.3
No. 6	4.9	8.7	2.1	3.3	3.3	4.9	2.6	3.5	3.1	2.6	3.2	3.9
No. 7	5.3	4.4	5.1	4.0	2.6	5.1	4.4	4.7	4.1	2.9	2.6	3.7
No. 8	6.0	5.2	7.1	4.0	3.3	3.8	3.6	4.6	3.3	2.3	3.3	3.4
No. 9	10.0	3.3	3.8	7.1	4.0	4.1	3.6	3.3	3.3	3.2	3.4	3.0
No. 10	6.6	3.5	5.2	4.0	4.3	5.3	2.9	2.9	4.4	2.9	2.5	3.2
Average	5.2	4.9	5.0	3.7	3.9	4.6	3.2	3.7	4.0	2.9	3.3	3.4
AVERAGES OF 5 HIGH-EARLY-STRENGTH CEMENTS												
No. 1	3.1	4.7	5.9	3.3	3.0	4.0	2.8	3.3	4.0	4.2	2.2	2.5
No. 2	1.5	2.5	2.5	2.3	2.1	1.6	2.0	1.4	2.7	1.9	1.3	1.3
No. 3	2.6	2.2	4.2	3.0	3.4	3.3	2.4	2.4	2.5	1.8	1.8	2.4
No. 4	4.3	4.7	4.2	3.8	2.6	4.5	3.1	4.0	4.2	2.8	3.2	4.6
No. 5	2.5	5.9	5.8	2.6	4.1	2.3	2.0	5.2	2.9	1.8	6.5	2.7
No. 6	2.6	6.1	2.5	2.0	2.6	1.5	2.7	3.0	2.7	2.7	1.9	1.7
No. 7	4.3	4.7	2.5	2.7	2.9	3.9	2.7	2.1	3.8	3.9	3.4	4.9
No. 8	4.9	3.1	4.6	3.1	2.6	3.2	3.6	3.2	3.3	2.0	2.3	3.7
No. 9	7.6	3.1	2.5	6.2	3.5	4.1	3.8	3.2	4.2	2.4	3.6	4.1
No. 10	3.0	5.0	5.0	2.7	2.1	2.2	3.4	4.3	2.9	3.3	2.8	3.9
Average	3.6	4.2	4.0	3.2	2.9	3.1	2.8	3.2	3.3	2.7	2.9	3.2

TABLE VI.—RESULTS OF CONCRETE TESTS BY LABORATORIES NOS. 9 AND 10.

3 by 6-in. Cylinders; 0 to ¾-in. Aggregate; Water-Cement Ratio 1.00.

Cement	Mix by Weight	Weight per Liter, g.	Calculated Voids-Cement Ratio (V/C)[a]	Slump, in.	Compressive Strength, lb. per sq. in.			
					1-Day	3-Day	7-Day	28-Day
LABORATORY No. 9 (Each value is average of 8 cylinders, made on different days.) NORMAL PORTLAND CEMENTS								
No. 1	1:3.37:3.83	not made	....	2.3	440	1120	1800	2790
No. 2	1:3.37:3.83	not made	....	1.9	430	1420	2720	4010
No. 3	1:3.37:3.83	not made	....	3.6	830	1830	2870	3960
No. 4	1:3.75:4.26	not made	....	3.5	380	1000	1670	2710
No. 5	1:3.37:3.83	not made	....	2.2	390	1310	2330	3670
No. 6	1:3.37:3.83	not made	....	2.6	420	1280	2310	3530
No. 7	1:3.56:4.05	not made	....	2.0	400	1370	2320	3360
Average	1:3.45:3.92			2.6	470	1333	2289	3433
HIGH-EARLY-STRENGTH CEMENTS								
No. 8	1:3.37:3.83	not made	....	2.5	970	2590	3760	4960
No. 9	1:3.37:3.83	not made	....	2.0	1220	2520	3610	4430
No. 10	1:3.37:3.83	not made	....	3.0	1140	2910	4050	4820
No. 11	1:3.75:4.26	not made	....	2.5	1280	2410	3020	3490
No. 12	1:3.37:3.83	not made	....	2.3	1130	3210	4340	5280
Average	1:3.45:3.92			2.5	1148	2728	3756	4596
LABORATORY No. 10 (Each value is average of 9 cylinders, made on different days.) NORMAL PORTLAND CEMENTS								
No. 1	1:5.84	2357	1.01	2.0	588	1412	2191	3463
No. 2	1:5.82	2380	0.95	2.2	561	1557	2790	4560
No. 3	1:5.69	2382	1.02	3.1	914	2003	2924	4235
No. 4	1:5.91	2375	0.98	2.6	455	1194	2076	3436
No. 5	1:5.78	2370	0.99	1.7	434	1526	2791	4517
No. 6	1:5.73	2375	0.98	2.3	427	1463	2650	4155
No. 7	1:5.73	2350	1.02	2.9	464	1463	2517	3772
Average	1:5.79	2370	0.99	2.4	549	1517	2563	4020
HIGH-EARLY-STRENGTH CEMENTS								
No. 8	1:5.64	2380	0.96	2.9	1007	2657	3967	5408
No. 9	1:5.73	2370	0.98	2.4	1545	3055	4349	5487
No. 10	1:5.60	2358	1.00	2.1	1355	3322	4653	5888
No. 11	1:6.50	2277	1.25	3.2	1127	2445	3359	4109
No. 12	1:5.78	2374	0.98	2.6	1109	3557	5262	6020
Average	1:5.85	2352	1.03	2.6	1229	3007	4318	5382

[a] Voids-cement ratio expressed in same terms as water-cement ratio.

2.4 per cent, and for standard Ottawa sand cubes 2.5 per cent. Since the values given in Table IV were obtained by averaging the percentage mean variations of the three test specimens from a batch for seven cements in one group and five cements in the other group and for four repetitions of the tests, similar tables were prepared, but not presented here, in which one cement in each group, tested on one day, was recorded. This study was made using cements Nos. 1 and 8, Nos. 2 and 9, and Nos. 3 and 10, tested on the first day and the same cements tested on the fourth day. Each of these tables shows the same relative uniformities for briquets and cubes as is shown in Table IV.

TABLE VII.—COMPRESSIVE STRENGTH OF CONCRETE MADE BY LABORATORIES NOS. 9 AND 10, AND COMPRESSIVE STRENGTH OF PLASTIC MORTARS MADE BY TEN LABORATORIES.

Concrete and Mortar		Weight per Liter, g.	Calculated Voids-Cement Ratio (V/C)[a]	Compressive Strength, lb. per sq. in.			
				1-Day	3-Day	7-Day	28-Day
AVERAGES OF 7 NORMAL PORTLAND CEMENTS							
Concrete	Laboratory No. 9 Results	not made	....	470	1333	2289	3433
	Laboratory No. 10 Results	2370	0.99	549	1517	2563	4020
	Average, Laboratories Nos. 9 and 10	....	....	509	1425	2426	3726
Mortar Cubes	Standard Ottawa Sand, Averages of 10 Laboratories	2100	1.06	410	1191	2234	4060
	Graded Ottawa Sand, Averages of 10 Laboratories	2126	0.98	537	1526	2744	4656
AVERAGES OF 5 HIGH-EARLY-STRENGTH CEMENTS							
Concrete	Laboratory No. 9 Results	not made	....	1148	2728	3756	4596
	Laboratory No. 10 Results	2352	1.03	1229	3007	4318	5382
	Averages of Laboratories Nos. 9 and 10	....	....	1188	2867	4037	4989
Mortar Cubes	Standard Ottawa Sand, Averages of 10 Laboratories	2113	1.04	1175	2969	4217	5455
	Graded Ottawa Sand, Averages of 10 Laboratories	2143	0.96	1460	3614	5038	6329

[a] Voids-cement ratio expressed in same terms as water-cement ratio.

The better uniformity of the plastic mortar cubes relative to briquets in the case of specimens made from the same batch was noted also in some of the previous investigations of Committee C-1. The superiority of the cube over the briquet in this respect suggests the possibility of further improvement in uniformity of cube strengths between laboratories as methods and equipment improve.

Uniformity of Strength Within Laboratories.—Table V shows the performance of each laboratory as to uniformity in tests repeated on four days. There is not much difference between the uniformity of briquets and of cubes or between the two types of cubes. The grand average percentage mean variation for briquets is 3.4 per cent, for graded Ottawa sand cubes 3.6 per cent, and for standard Ottawa sand cubes 3.8 per cent. Again these figures indicate the possibility of improving the uniformity of cube strengths between laboratories.

Concrete Tests.—The concrete test results obtained by Laboratories Nos. 9 and 10 are given in Table VI and for comparison these values together with the average values of cubes obtained by the ten laboratories are given in Table VII. Both laboratories used the same water-cement ratio of 1.00 in the concrete and obtained about the same slumps but the curing conditions, the aggregate, the proportions of cement and aggregate and the proportions of sand and gravel were different. The sand (0 to No. 4) content of the aggregate was 46.8 per cent for Laboratory No. 9 and 56.8 per cent for Laboratory No. 10, and the proportions of cement and aggregate were 1:7.37 and 1:5.82 by weight, respectively. Although some difference in strength results was obtained by the two laboratories, no doubt due to the above mentioned variables, their average strength values are typical of this grade of concrete and may be considered satisfactory for comparison with the cube and briquet strengths.

Voids-Cement Ratio of Mortar.—In Table VIII are given the flow, weight per liter of mortar, and the voids-cement ratio (V/C), calculated by means of the following formula:[1]

$$\text{Voids-cement ratio, } V/C = \left(\frac{B}{D} - \frac{A}{2650} - \frac{E}{3100}\right)\frac{1505}{E} \quad \text{(grams and liters)}$$

where V = voids (air and water) in a batch of mortar or concrete;

C = volume of cement in a batch (based on 1505 g. = 1 liter or 94 lb. = 1 cu. ft.);

E = weight of cement in a batch of mortar or concrete;

A = weight of room-dry aggregate in a batch of mortar or concrete;

H = weight of water in a batch of mortar or concrete;

B = weight of batch = $E + A + H$, and

D = weight of unit volume of fresh mortar or concrete.

Since the batches used by each laboratory for determining weight per liter of mortar were identical, the formula was further simplified as follows:

GRADED OTTAWA SAND	STANDARD OTTAWA SAND
$A = 1570$	$A = 1650$
$E = 570$	$E = 550$
$H = 302$	$H = 290$
$B = 2442$	$B = 2490$
$V/C = \frac{6446.9}{D} - 2.05$	$V/C = \frac{6797.7}{D} - 2.18$

---

[1] O. L. Moore, "A Compression Test for Portland Cement," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part II, p. 570 (1929).

TABLE VIII.—RESULTS OF FLOW TESTS, WEIGHT PER LITER OF MORTAR AND CALCULATED VOIDS-CEMENT RATIO.

(Tests not repeated on different days.)

NORMAL PORTLAND CEMENTS

	Laboratory[a]	Graded Ottawa Sand Mortar, 1:2.75 by Wt., $W/C = 0.8$				Standard Ottawa Sand Mortar, 1:3 by Wt., $W/C = 0.8$			
		Date Made in 1933	Flow, per cent	Weight per Liter, g.	Calculated Voids-Cement Ratio (V/C)[b]	Date Made in 1933	Flow, per cent	Weight per Liter, g.	Calculated Voids-Cement Ratio (V/C)[b]
Cement No. 1	No. 1	3/15	72	2123	0.99	3/15	63	2080	1.09
	No. 2	3/14	75	2089	1.04	3/14	75	2055	1.13
	No. 3	5/2	87	2055	1.09	5/2	88	2023	1.18
	No. 5	5/26	57	2121	0.99	5/26	62	2129	1.01
	No. 6	5/25	79	2100	1.03	5/25	80	2110	1.05
	No. 7	5/12	73	2101	1.02	5/12	64	2085	1.08
	No. 8	3/22	38	2103	1.01	3/21	39	2063	1.11
	No. 9	6/14	80	2128	0.98	6/15	85	2089	1.07
	No. 10	6/10	40	2060	1.08	6/10	42	2018	1.19
Average			67	2098	1.02		66	2072	1.10
Percentage mean variation			21.5	0.9	2.9		20.9	1.4	4.1
Cement No. 2	No. 1	3/18	86	2150	0.95	3/18	75	2110	1.04
	No. 2	3/14	65	2127	0.98	3/14	55	2086	1.08
	No. 3	5/2	84	2126	0.98	5/2	89	2053	1.13
	No. 5	5/26	40	2159	0.94	5/26	52	2133	1.01
	No. 6	5/25	72	2140	0.97	5/25	62	2160	0.98
	No. 7	5/12	74	2119	0.99	5/12	61	2109	1.04
	No. 8	3/22	45	2124	0.98	3/21	36	2086	1.08
	No. 9	6/14	74	2147	0.95	6/15	65	2130	1.01
	No. 10	6/10	39	2112	1.00	6/10	28	2086	1.08
Average			64	2134	0.97		58	2106	1.05
Percentage mean variation			24.1	0.6	1.7		23.6	1.2	3.6
Cement No. 3	No. 1	3/20	90	2147	0.95	3/20	75	2107	1.05
	No. 2	3/22	90	2129	0.98	3/22	80	2100	1.06
	No. 3	5/2	87	2131	0.97	5/2	87	2097	1.06
	No. 5	5/26	45	2149	0.95	5/26	57	2159	0.97
	No. 6	5/25	84	2140	0.97	5/25	74	2140	1.01
	No. 7	5/12	91	2150	0.95	5/12	65	2091	1.07
	No. 8	3/22	46	2151	0.95	3/21	45	2099	1.06
	No. 9	6/14	82	2160	0.93	6/15	74	2134	1.00
	No. 10	6/10	55	2129	0.98	6/10	42	2081	1.08
Average			74	2143	0.96		66	2112	1.04
Percentage mean variation			23.4	0.4	1.4		19.4	1.0	3.0
Cement No. 4	No. 1	3/21	90	2145	0.95	3/21	83	2111	1.04
	No. 2	3/22	85	2112	1.00	3/22	75	2067	1.11
	No. 3	5/3	96	2102	1.02	5/3	97	2072	1.10
	No. 5	5/26	55	2149	0.95	5/26	85	2151	0.98
	No. 6	5/25	102	2140	0.97	5/25	88	2140	1.01
	No. 7	5/12	91	2125	0.98	5/12	75	2125	1.02
	No. 8	3/24	52	2144	0.96	3/23	47	2084	1.08
	No. 9	6/14	90	2160	0.93	6/15	88	2133	1.01
	No. 10	6/10	67	2120	0.99	6/10	52	2069	1.10
Average			81	2133	0.97		77	2106	1.05
Percentage mean variation			18.8	0.7	2.3		16.6	1.4	4.0
Cement No. 5	No. 1	3/22	71	2112	1.00	3/22	75	2100	1.06
	No. 2	3/28	70	2089	1.04	3/28	70	2077	1.09
	No. 3	5/3	83	2092	1.03	5/3	97	2090	1.07
	No. 5	5/29	55	2169	0.92	5/29	60	2142	0.99
	No. 6	5/25	80	2120	1.00	5/25	80	2140	1.01
	No. 7	5/12	71	2090	1.03	5/12	62	2105	1.05
	No. 8	3/24	31	2096	1.02	3/23	47	2068	1.11
	No. 9	6/14	71	2129	0.98	6/15	75	2111	1.04
	No. 10	6/10	70	2108	1.01	6/10	42	2065	1.11
Average			67	2112	1.00		67	2100	1.06
Percentage mean variation			15.7	0.9	2.5		19.7	1.0	3.0
Cement No. 6	No. 1	3/23	87	2160	0.93	3/23	71	2126	1.02
	No. 2	3/28	75	2137	0.97	3/28	65	2102	1.05
	No. 3	5/3	87	2134	0.97	5/3	93	2113	1.04
	No. 5	5/29	45	2142	0.96	5/29	62	2142	0.99
	No. 6	5/25	90	2150	0.96	5/25	65	2160	0.98
	No. 7	5/12	76	2129	0.98	5/12	63	2098	1.06
	No. 8	3/24	49	2136	0.97	3/23	46	2093	1.06
	No. 9	6/14	77	2158	0.94	6/15	75	2133	1.01
	No. 10	6/10	52	2144	0.96	6/10	41	2090	1.07
Average			71	2143	0.96		64	2117	1.03
Percentage mean variation			20.8	0.4	1.1		16.1	0.9	2.7

[a] These tests not made by Laboratory No. 4.

[b] Voids-cement ratio expressed in same terms as water-cement ratio

TABLE VIII.—(*Continued*).

(Tests not repeated on different days.)

NORMAL PORTLAND CEMENTS

	Laboratory[a]	Graded Ottawa Sand Mortar, 1:2.75 by Wt., $W/C = 0.8$				Standard Ottawa Sand Mortar, 1:3 by Wt., $W/C = 0.8$			
		Date Made in 1933	Flow, per cent	Weight per Liter, g.	Calculated Voids-Cement Ratio $(V/C)^b$	Date Made in 1933	Flow, per cent	Weight per Liter, g.	Calculated Voids-Cement Ratio $(V/C)^b$
Cement No. 7.....	No. 1..........	3/24	90	2140	0.96	3/24	83	2124	1.02
	No. 2..........	4/3	85	2102	1.02	4/3	80	2057	1.12
	No. 3..........	5/4	100	2083	1.04	5/4	105	2042	1.15
	No. 5..........	5/29	57	2129	0.98	5/29	72	2133	1.01
	No. 6..........	5/25	97	2110	1.01	5/25	88	2120	1.04
	No. 7..........	5/12	91	2115	1.00	5/12	75	2055	1.13
	No. 8..........	3/28	56	2128	0.98	3/27	67	2083	1.08
	No. 9..........	6/14	91	2150	0.95	6/15	95	2114	1.03
	No. 10..........	6/10	68	2113	1.00	6/10	62	2058	1.12
Average..........		......	82	2119	0.99		81	2087	1.08
Percentage mean variation..........		......	17.2	0.7	2.3		13.2	1.5	4.3
Average of 7 Normal Portland Cements..		......	72	2126	0.98		68	2100	1.06
Percentage mean variation..........		......	7.9	0.6	1.8		8.5	0.5	1.7
HIGH-EARLY-STRENGTH CEMENTS									
Cement No. 8.....	No. 1..........	3/25	84	2166	0.93	3/25	67	2142	0.99
	No. 2..........	4/3	80	2157	0.94	4/3	65	2112	1.04
	No. 3..........	5/4	88	2137	0.97	5/4	79	2145	0.99
	No. 5..........	5/29	42	2189	0.89	5/29	67	2181	0.94
	No. 6..........	5/25	88	2180	0.92	5/25	64	2160	0.98
	No. 7..........	5/12	77	2125	0.98	5/12	50	2115	1.03
	No. 8..........	3/28	42	2163	0.93	3/27	43	2124	1.02
	No. 9..........	6/14	78	2176	0.91	6/15	59	2144	0.99
	No. 10..........	6/10	57	2163	0.93	6/10	44	2115	1.03
Average..........		......	71	2162	0.93		60	2137	1.00
Percentage mean variation..........		......	22.1	0.7	2.0		15.8	0.9	2.5
Cement No. 9.....	No. 1..........	3/27	95	2157	0.94	3/27	78	2148	0.98
	No. 2..........	4/11	80	2125	0.98	4/11	65	2107	1.05
	No. 3..........	5/4	93	2141	0.96	5/4	83	2135	1.00
	No. 5..........	5/29	45	2169	0.92	5/29	70	2169	0.95
	No. 6..........	5/25	88	2170	0.93	5/25	64	2150	0.99
	No. 7..........	5/12	78	2165	0.93	5/12	48	2115	1.03
	No. 8..........	3/28	30	2156	0.94	3/27	37	2114	1.03
	No. 9..........	6/14	81	2171	0.92	6/15	65	2139	1.00
	No. 10..........	6/10	52	2134	0.97	6/10	38	2113	1.04
Average..........		......	71	2154	0.94		61	2132	1.01
Percentage mean variation..........		......	27.3	0.6	1.8		21.6	0.8	2.7
Cement No. 10.....	No. 1..........	3/28	90	2170	0.92	3/28	69	2140	1.00
	No. 2..........	4/11	80	2154	0.94	4/11	65	2115	1.03
	No. 3..........	5/5	94	2132	0.97	5/5	86	2108	1.04
	No. 5..........	5/29	45	2169	0.92	5/29	67	2159	0.97
	No. 6..........	5/25	91	2180	0.92	5/25	66	2140	1.01
	No. 7..........	5/12	88	2155	0.94	5/12	56	2130	1.01
	No. 8..........	3/30	48	2141	0.96	3/29	27	2109	1.04
	No. 9..........	6/14	82	2180	0.91	6/15	64	2153	0.98
	No. 10..........	6/10	53	2140	0.96	6/10	42	2112	1.04
Average..........		......	74	2158	0.94		60	2129	1.01
Percentage mean variation..........		......	23.5	0.7	1.9		20.7	0.8	2.1
Cement No. 11.....	No. 1..........	3/29	95	2104	1.01	3/29	94	2065	1.11
	No. 2..........	4/17	90	2077	1.05	4/17	95	2022	1.18
	No. 3..........	5/5	97	2050	1.09	5/5	106	2001	1.22
	No. 5..........	5/29	72	2055	1.09	5/29	72	2142	0.99
	No. 6..........	5/25	91	2070	1.07	5/25	99	2030	1.18
	No. 7..........	5/12	86	2065	1.07	5/12	80	2055	1.13
	No. 8..........	3/30	57	2115	1.00	3/29	70	2057	1.12
	No. 9..........	6/15	99	2086	1.04	6/15	105	1999	1.22
	No. 10..........	6/10	71	2101	1.02	6/10	63	2016	1.19
Average..........		......	84	2080	1.05		87	2043	1.15
Percentage mean variation..........		......	14.0	0.9	2.7		16.2	1.6	4.7
Cement No. 12.....	No. 1..........	3/30	88	2168	0.92	3/30	68	2150	0.98
	No. 2..........	4/17	80	2152	0.95	4/17	70	2009	1.20
	No. 3..........	5/5	92	2120	0.99	5/5	93	2136	1.00
	No. 5..........	5/29	45	2172	0.92	5/29	67	2179	0.94
	No. 6..........	5/25	88	2170	0.93	5/25	68	2160	0.98
	No. 7..........	5/12	78	2195	0.89	5/12	52	2115	1.03
	No. 8..........	3/30	57	2152	0.95	3/29	58	2112	1.04
	No. 9..........	6/15	81	2183	0.90	6/15	72	2152	0.98
	No. 10..........	6/10	51	2142	0.96	6/10	38	2112	1.04
Average..........			73	2161	0.93		65	2125	1.02
Percentage mean variation..........			20.5	0.8	2.6		16.1	1.6	4.9
Average of 5 High-Early-Strength Cements......			75	2143	0.96		67	2113	1.04
Percentage mean variation..........			5.3	1.2	3.9		12.5	1.3	4.4
Average of 12 Cements..........			73	2133	0.97		68	2105	1.05
Percentage mean variation..........			6.4	1.0	2.9		10.6	0.9	2.9

[a] These tests not made by Laboratory No. 4.

[b] Voids-cement ratio expressed in same terms as water-cement ratio.

It is interesting to note the wide variation in flow test results as compared with the close uniformity obtained between the laboratories in measuring the weight per liter of the mortar, which in turn resulted in quite uniform results for the voids-cement ratio (V/C). The uniformity of the weight per liter values, of course, is due largely to the high degree of uniformity of balances and measures, while the uniformity of the calculated V/C may be attributed to the accurate unit weights of the mortar, the practically constant specific gravities of cement and of pure silica sand, and to the fact that the pure silica sand does not absorb water. Since the compressive strength of mortar and concrete is generally accepted as a function of the V/C, the committee believes that further study should be given V/C as offering a possible further refinement if used as a basis for strength. For example, the voids-cement ratio (V/C) in these graded Ottawa sand mortars might have been specified as $0.97 + 0.03$ instead of the water-cement ratio (W/C) as 0.80. In many cases the first batch using $W/C = 0.80$ would have met the V/C requirement. In those cases where it did not, the W/C could have been readily estimated to obtain the specified V/C in the second batch. It seems reasonable to expect that this method might maintain the plasticity within a workable range at all times for if the consistency is too dry or too wet for the best results in molding cubes, due either to the cement or to the grading of the sand or both, then the unit weight of mortar would be affected, which in turn would affect the calculated V/C. By maintaining a constant V/C within reasonable limits, extreme cases of consistency might be taken care of without introducing the errors which are known to accompany present methods of measuring consistency.

Miscellaneous Tests.—Table IX summarizes the results of measuring a large number of cube dimensions. About 65 per cent of the dimensions of the faces in contact with the testing machine were reported as exactly 2 in. The deviations from 2 in. of the remaining 35 per cent were averaged for each laboratory and the average values fall within ± 0.03 in., 20 per cent being plus and 15 per cent minus. The plus signs predominate as a result of instructions to finish the cubes about $\frac{1}{64}$ in. above the tops of the molds, although the average minus deviations were greater than the average plus deviations. A very few individual dimensions varied from 2 in. by as much as ± 0.06 in. but practically all individual dimensions come within a deviation of ± 0.03 in. and a very high percentage within ± 0.02 in.

Table X summarizes the results of miscellaneous tests on the various cements. The normal consistency of the cements as determined by averages of the results of ten laboratories ranged from 22.4 to 26.3

TABLE IX.—DIMENSIONS OF CUBES.

Four dimensions of each face in contact with testing machine measured; in general, four cubes (one for each period) of each cement.

Laboratory	Graded Ottawa Sand						Standard Ottawa Sand					
	Dimensions Measured				Average Deviation		Dimensions Measured				Average Deviation	
	Number of Measurements	Per cent Measuring 2 in.	Per cent Above 2 in.	Per cent Below 2 in.	Above 2 in.	Below 2 in.	Number of Measurements	Per cent Measuring 2 in.	Per cent Above 2 in.	Per cent Below 2 in.	Above 2 in.	Below 2 in.
1-DAY SPECIMENS												
No. 1	96	73	0	27	0	0.03	96	84	0	16	0	0.03
No. 2	96	73	21	6	0.01	0.02	96	78	14	8	0.01	0.01
No. 3	384	61	20	19	0.01	0.01	384	52	31	17	0.01	0.01
No. 4	....	...	...	...	....	....	....	...	...	...	....	....
No. 5	96	41	54	5	0.01	0.01	96	47	43	10	0.01	0.01
No. 6	96	28	51	21	0.01	0.01	96	34	42	24	0.01	0.01
No. 7	96	49	18	33	0.01	0.02	96	54	16	30	0.02	0.02
No. 8	192	100	0	0	0	0	192	98	2	0	0.03	0
No. 9	576	55	24	21	0.01	0.01	576	60	25	15	0.01	0.01
No. 10	192	95	1	4	0.03	0.03	192	98	0	2	0	0.03
All	1824	65	19	16	0.010	0.015	1824	66	21	13	0.011	0.014
3-DAY SPECIMENS												
No. 1	96	84	0	16	0	0.03	96	78	0	22	0	0.03
No. 2	96	72	22	6	0.01	0.01	96	70	29	1	0.01	0.01
No. 3	380	64	18	18	0.01	0.01	384	59	17	24	0.01	0.01
No. 4	....	...	...	...	....	....	....	...	...	...	....	....
No. 5	96	27	70	3	0.01	0.01	96	38	55	7	0.01	0.01
No. 6	96	20	56	24	0.01	0.02	96	25	41	34	0.01	0.02
No. 7	96	48	12	40	0.01	0.02	96	34	21	45	0.01	0.02
No. 8	192	99	0	1	0	0.01	192	99	1	0	0.03	0
No. 9	576	51	15	34	0.01	0.01	456	60	19	21	0.01	0.01
No. 10	192	93	0	7	0	0.03	192	95	0	5	0	0.03
All	1820	63	17	20	0.007	0.017	1704	65	17	18	0.010	0.015
7-DAY SPECIMENS												
No. 1	96	86	0	14	0	0.03	96	86	0	14	0	0.03
No. 2	96	64	30	6	0.01	0.01	96	75	23	2	0.01	0.01
No. 3	384	64	18	18	0.01	0.01	384	56	26	18	0.01	0.01
No. 4	....	...	...	...	....	....	....	...	...	...	....	....
No. 5	96	29	58	13	0.01	0.01	96	32	46	22	0.01	0.01
No. 6	96	23	47	30	0.01	0.02	96	23	64	13	0.02	0.01
No. 7	96	36	15	49	0.01	0.01	96	44	19	37	0.01	0.01
No. 8	192	100	0	0	0	0	192	99	1	0	0.01	0
No. 9	504	58	24	18	0.01	0.01	576	59	30	11	0.01	0.01
No. 10	192	94	0	6	0	0.03	192	97	0	3	0	0.03
All	1752	65	19	16	0.007	0.014	1824	65	23	12	0.009	0.013
28-DAY SPECIMENS												
No. 1	96	92	0	8	0	0.03	96	89	0	11	0	0.03
No. 2	96	74	25	1	0.01	0.01	96	74	26	0	0.01	0.01
No. 3	384	65	15	20	0.01	0.01	384	67	12	21	0.01	0.01
No. 4	96	33	47	19	0.01	0.01	96	40	45	15	0.02	0.02
No. 5	96	33	64	3	0.01	0.01	96	38	61	1	0.01	0.01
No. 6	96	15	51	34	0.02	0.01	96	26	57	17	0.01	0.01
No. 7	96	44	14	42	0.01	0.01	96	49	20	31	0.01	0.01
No. 8	192	98	1	1	0.01	0.01	192	98	2	0	0.02	0
No. 9	576	49	36	15	0.01	0.01	492	57	23	20	0.01	0.01
No. 10	192	95	0	5	0	0.03	192	97	0	3	0	0.03
All	1920	61	25	14	0.009	0.014	1836	66	20	14	0.010	0.014
DATA FROM ALL LABORATORIES FOR ALL PERIODS (1, 3, 7 AND 28 DAYS)												
Grand Total	7316	64	20	16	0.008	0.015	7188	66	20	14	0.010	0.014

TABLE X.—RESULTS OF CEMENT TESTS BY STANDARD METHODS C 77 – 32.[a]

(Tests not repeated on different days.)

NORMAL PORTLAND CEMENTS

	Laboratory	Date Made in 1933	Normal Consistency, per cent water	Time of Setting, Gillmore Method				Residue on No. 200 Sieve, per cent	Soundness	Remarks by Laboratories
				Initial Set		Final Set				
				hr.	min.	hr.	min.			
Cement No. 1	No. 1	3/15	25.0	3	25	4	45	8.5	OK	
	No. 2	3/14	24.0	5	00	8	00	6.9	OK	
	No. 3	3/16	24.0	4	10	5	25	8.0	OK	
	No. 4	5/2	23.6	5	00	..	..	6.9	OK	
	No. 5	3/14	23.5	3	15	6	30	7.5	OK	
	No. 6	5/4	24.0	5	10	7	30	7.2	OK	
	No. 7	3/13	23.0	2	45	4	37	9.6	OK	
	No. 8	3/21	24.5	4	40	6	55	7.4	OK	False set.
	No. 9	9/25–27	24.0	4	40	8	30	7.4	OK	
	No. 10	4/7	23.0	4	00	6	30	7.6	OK	False set.
Average			23.9	4	12	6	31	7.7		
Cement No. 2	No. 1	3/18	26.5	4	45	7	45	5.6	OK	False set.
	No. 2	3/14	25.0	5	44	8	59	5.0	OK	
	No. 3	3/17	25.5	4	05	6	05	5.1	OK	
	No. 4	5/2	26.0	5	45	..	..	4.6	OK	
	No. 5	3/20	26.5	3	45	6	30	5.5	OK	False set.
	No. 6	5/4	26.0	5	20	7	50	5.0	OK	
	No. 7	3/13	23.0	2	43	4	28	6.5	OK	
	No. 8	3/21	25.6	4	15	6	15	4.6	OK	False set.
	No. 9	9/25–27	25.5	5	30	9	10	4.9	OK	
	No. 10	4/7	24.0	4	05	6	20	5.1	OK	
Average			25.4	4	36	7	02	5.2		
Cement No. 3	No. 1	3/20	25.5	3	10	4	40	2.7	OK	
	No. 2	3/21	26.5	3	50	6	30	3.1	OK	
	No. 3	3/17	26.0	3	45	5	10	2.7	OK	
	No. 4	9/27	26.4	3	50	6	50	1.8	OK	
	No. 5	3/24	27.0	3	00	5	30	1.8	OK	
	No. 6	5/4	27.5	4	40	7	30	2.0	OK	
	No. 7	3/13	25.0	2	38	4	37	2.0	OK	
	No. 8	3/21	26.8	3	55	5	25	2 3	OK	False set.
	No. 9	9/25–27	26.0	3	50	5	45	1.6	OK	
	No. 10	4/7	26.0	4	20	6	35	1.8	OK	
Average			26.3	3	42	5	51	2.2		
Cement No. 4	No. 1	3/21	23.5	2	50	4	50	3.4	OK	
	No. 2	3/21	24.0	4	34	7	49	3.4	OK	
	No. 3	3/17	24.5	2	50	4	35	3.0	OK	
	No. 4	9/27	22.4	2	45	5	55	2.7	OK	
	No. 5	4/27	23.0	3	00	6	00	3.0	OK	
	No. 6	5/4	24.5	4	00	7	20	3.0	OK	
	No. 7	3/14	23.0	2	25	4	30	3.5	OK	
	No. 8	3/23	23.2	2	50	4	50	3.0	OK	
	No. 9	9/25–27	25.0	4	30	7	40	2.2	OK	
	No. 10	4/10	23.5	4	00	6	15	2.8	OK	
Average			23.7	3	22	5	58	3.0		
Cement No. 5	No. 1	3/22	23.0	4	55	5	45	12.4	OK	
	No. 2	3/27	23.0	3	57	4	47	12.2	OK	
	No. 3	3/20	23.5	2	50	4	25	12.2	OK	
	No. 4	5/3	23.0	3	45	5	15	11.1	OK	
	No. 5	4/27	24.0	3	00	5	15	11.9	OK	
	No. 6	5/4	24.0	3	30	6	30	11.5	OK	
	No. 7	3/14	23.0	3	10	4	30	14.4	OK	
	No. 8	3/23	23.6	3	00	4	45	11.4	OK	
	No. 9	9/25–27	24.0	4	40	7	30	11.4	OK	
	No. 10	4/10	23.5	3	30	6	05	11.5	OK	
Average			23.5	3	38	5	29	12.0		
Cement No. 6	No. 1	3/23	25.0	5	00	7	15	3.9	OK	
	No. 2	3/27	25.0	5	05	7	15	3.8	OK	
	No. 3	3/20	24.6	3	30	5	15	3.8	OK	
	No. 4	5/3	23.6	4	25	..	..	3.2	OK	
	No. 5	5/5	24.5	3	45	6	15	3.9	OK	
	No. 6	5/4	26.0	5	20	7	40	3.5	OK	
	No. 7	3/14	24.0	2	45	4	08	5.5	OK	
	No. 8	3/23	25.0	4	10	5	40	3.6	OK	
	No. 9	9/25–27	25.5	5	15	8	40	3.9	OK	
	No. 10	4/10	24.0	4	45	6	40	3.8	OK	
Average			24.7	4	24	6	32	3.9		

---

[a] **Standard Methods of Sampling and Testing** Portland Cement (C 77 – 32), **see 1933 Book of A.S.T.M. Standards Part II, p. 6.**

TABLE X.—(*Continued*)

(Tests not repeated on differen[illegible]

NORMAL PORTLAND CEMENTS

	Laboratory	Date Made in 1933	Normal Consistency, per cent water	Time of Setting, Gillmore Method				Residue on No. 200 Sieve, per cent	Soundness	Remarks by Laboratories
				Initial Set		Final Set				
				hr.	min.	hr.	min.			
Cement No. 7......	No. 1.........	3/24	24.0	4	30	6	20	8.7	OK	
	No. 2.........	4/3	22.0	4	38	8	00	8.0	OK	
	No. 3.........	3/20	22.0	3	15	4	25	8.4	OK	
	No. 4.........	5/10	20.8	3	45	6	00	7.9	OK	
	No. 5.........	5/5	22.0	3	45	5	45	8.4	OK	
	No. 6.........	5/4	23.5	5	10	7	20	8.0	OK	
	No. 7.........	3/15	23.0	3	04	4	30	10.9	OK	
	No. 8.........	3/27	22.0	3	50	5	35	7.9	OK	
	No. 9.........	9/26–28	23.0	4	35	9	15	8.2	OK	
	No. 10.........	4/12	22.0	4	30	7	00	8.1	OK	
Average..........	....	....	22.4	4	06	6	25	8.4		
Average of 7 Normal Portland Cements.		....	24.3	4	00	6	15	6.0		
HIGH-EARLY-STRENGTH CEMENTS										
Cement No. 8.....	No. 1.........	3/25	26.5	3	05	4	40	1.0	OK	
	No. 2.........	4/3	27.0	3	45	6	22	0.5	OK	
	No. 3.........	3/21	27.0	2	20	3	50	1.3	OK	
	No. 4.........	6/13	26.5	3	30	5	45	0.4	OK	
	No. 5.........	5/11	27.0	2	45	4	45	0.5	OK	
	No. 6.........	5/4	27.0	3	10	6	00	0.7	OK	
	No. 7.........	3/15	26.0	2	40	4	15	0.4	OK	
	No. 8.........	3/27	27.0	2	40	4	55	1.2	OK	
	No. 9.........	9/26–28	27.5	4	15	7	15	0.4	OK	
	No. 10.........	4/12	26.5	3	05	5	15	0.5	OK	
Average..........	....	....	26.8	3	07	5	18	0.7		
Cement No. 9.....	No. 1.........	3/27	25.0	2	50	3	10	2.9	OK	
	No. 2.........	4/10	25.0	2	53	4	28	2.0	OK	
	No. 3.........	3/21	25.0	1	55	3	25	3.6	OK	False set.
	No. 4.........	6/13	25.5	3	15	5	30	1.9	OK	
	No. 5.........	5/11	26.5	1	45	4	30	2.3	OK	Sticky.
	No. 6.........	5/4	27.0	3	10	5	40	1.9	OK	
	No. 7.........	3/15	25.0	2	18	4	05	1.6	OK	
	No. 8.........	3/27	25.2	2	15	4	15	2.4	OK	
	No. 9.........	9/26–28	26.0	3	10	5	50	1.3	OK	
	No. 10.........	4/12	25.5	2	40	4	50	1.8	OK	
Average..........	....	....	25.6	2	37	4	34	2.2		
Cement No. 10.....	No. 1.........	3/28	25.5	1	00	4	30	1.4		Very slight warping.
	No. 2.........	4/10	27.5	3	27	7	02	1.7	OK	
	No. 3.........	3/21	27.0	0	30	4	05[a]	1.0	OK	
	No. 4.........	6/13	27.4	3	30	..	..	0.6	OK	
	No. 5.........	5/17	....	0	25	3	25	0.8	OK	Quick setting.
	No. 6.........	5/4	27.5	1	50	6	20	0.5	OK	False set.
	No. 7.........	3/17	25.0	0	13	3	30	0.3	OK	Quick setting.
	No. 8.........	3/29	28.4	0	50	5	15	1.3	OK	
	No. 9.........	9/26–28	28.0	1	10	6	15	0.3	OK	
	No. 10.........	4/14	27.0	2	50	6	40	0.2	OK	False set.
Average..........	....	....	27.0	1	34	5	14	0.8		
Cement No. 11.....	No. 1.........	3/29	25.5	3	15	4	15	1.3	OK	
	No. 2.........	4/17	26.5	3	08	6	13	0.8	OK	
	No. 3.........	3/21	25.5	2	40	4	45	1.8	OK	Water repellent.
	No. 4.........	6/13	26.8	4	45	..	..	0.7	OK	Water repellent.
	No. 5.........	5/17	25.0	3	00	5	15	1.3	OK	5 min. for absorption.
	No. 6.........	5/4	27.0	4	00	6	50	0.9	OK	Water repellent.
	No. 7.........	3/17	25.0	2	15	4	00	0.6	OK	
	No. 8.........	3/29	25.0	3	10	4	25	1.5	OK	
	No. 9.........	9/26–28	26.0	4	15	6	05	0.6	OK	
	No. 10.........	4/14	25.0	3	25	5	20	0.9	OK	Water repellent.
Average..........	....	....	25.7	3	23	5	14	1.0		
Cement No. 12.....	No. 1.........	3/30	25.0	5	00	7	45	3.2	OK	
	No. 2.........	4/17	25.0	5	10	8	40	3.0	OK	
	No. 3.........	3/21	25.0	3	05	5	20	3.5	OK	
	No. 4.........	6/13	23.8	4	45	..	..	2.5	OK	
	No. 5.........	5/19	26.0	4	00	7	15	3.8	OK	
	No. 6.........	5/4	26.5	5	00	9	10	2.7	OK	
	No. 7.........	3/17	24.0	2	40	5	05	3.0	OK	
	No. 8.........	3/29	24.4	3	30	6	00	2.8	OK	
	No. 9.........	9/26–28	25.0	5	30	9	05	2.0	OK	
	No. 10.........	4/14	24.5	5	25	8	00	2.4	OK	
Average................................			**24.9**	**4**	**24**	**7**	**22**	**2.9**		
Average of 5 High-Early-Strength Cements			**26.0**	**3**	**01**	**5**	**32**	**1.5**		

[a] Shrinkage cracks in pat.

per cent for the normal portland cements and from 24.9 to 27.0 per cent for the high-early-strength cements. The determinations of ten laboratories on individual cements varied by from 1.00 to 3.50 per cent. Some laboratories reported "false set" on five of the cements, "quick set" on one, and "water repellent" on another. These cements, in general, perform about the same as the others in uniformity of test results.

TABLE XI.—TEMPERATURE AND HUMIDITY DATA.

Laboratory	Date Specimens Made in 1933			Temperature, deg. Fahr.						Relative Humidity, per cent	
							Storage Water for				
	Start	Finish		Room	Mixing Water	Moist Closet	3-Day Specimens	7-Day Specimens	28-Day Specimens	Room	Moist Closet
No. 1	3/16	5/11	Average	70	70	70	70	70	70	64	94
			Maximum	77	73	70	75	75	75	83	94
			Minimum	67	69	70	67	67	67	42	94
No. 2	3/14	4/20	Average	72	70	70	69	69	69	57	100
			Maximum	76	71	73	72	72	73	85	100
			Minimum	67	69	68	67	67	67	45	100
No. 3	3/22	4/28	Average	82	70	73	70	70	70	30	99
			Maximum	86	72	78	72	73	78	57	100
			Minimum	80	68	66	68	68	68	18	98
No. 4	5/2	8/4	Average	70	70	70	69	69	69	60±5	95
			Maximum	75	71	77	79	79	88	...	...
			Minimum	68	68	68	64	64	64	...	...
No. 5	3/14	5/24	Average	78	70	71	70	70	70	44	87
			Maximum	...	...	75	75	75	76	...	95
			Minimum	...	...	68	67	67	67	...	81
No. 6	5/1	5/26	Average	70	70	70	70	70	70	71	100
			Maximum	72	...	71	71	71	71	84	100
			Minimum	68	...	69.5	69.5	69.5	69.5	48	100
No. 7	3/13	5/3	Average	75	70	70	71	71	71	46	98
			Maximum	...	...	74	74	74	74	...	100
			Minimum	...	...	64	67	67	67	...	90
No. 8	3/21	5/3	Average	76	73	70	70	70	70	43	97
			Maximum	82	80	76	73	75	...	74	100
			Minimum	70	68	64	67	67	...	30	95
No. 9	4/5	6/14	Average	71	70	70	69	69	69	58	99
			Maximum	75.5	70	72	71	71	...	78	100
			Minimum	66	70	69.5	69	69	...	44	90
No. 10	4/7	5/29	Average	75	70	70	71	71	70	59	97
			Maximum	80	71	71	71.5	71.5	71.5	82	98
			Minimum	71	69	69	70	70	69	44	95

Table XI summarizes temperature and humidity data of each laboratory during the period of making and curing test specimens.

Relations Existing Between Strength Results.—In Figs. 5 to 9 are shown the relations existing between the various strength results. The lines in the various figures were determined by plotting the average values of the seven normal portland cements and of the five high-early-strength cements obtained by the ten laboratories (two labora-

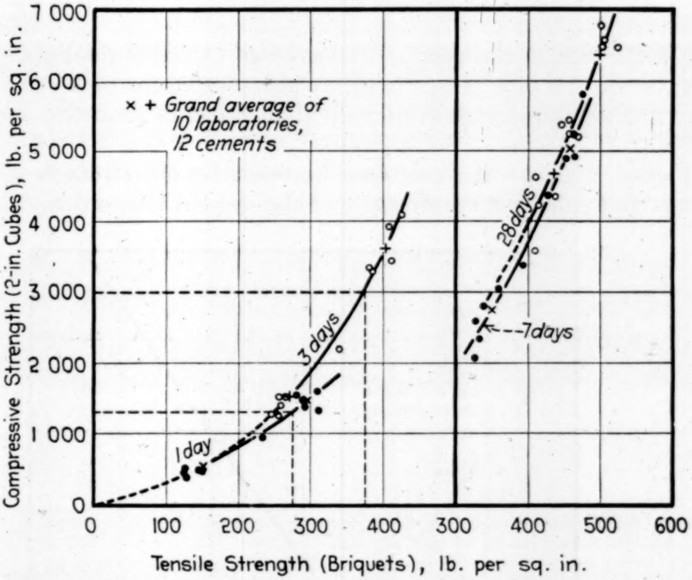


FIG. 5.—Relation of Tensile Strength of Standard Briquets to Compressive Strength of Plastic Mortar Cubes Using Graded Ottawa Sand. Averages of 10 Laboratories on 12 Cements.

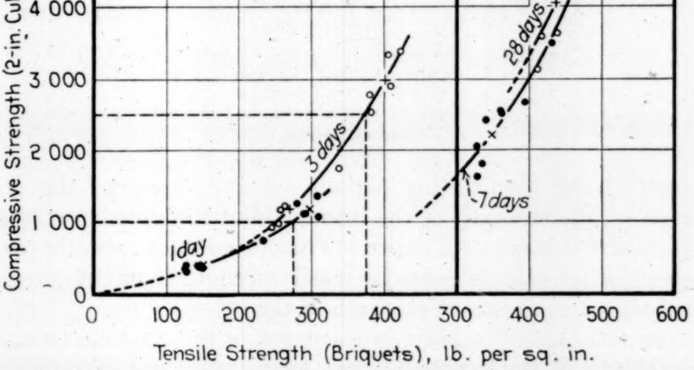


FIG. 6.—Relation of Tensile Strength of Standard Briquets to Compressive Strength of Plastic Mortar Cubes Using Standard Ottawa Sand. Averages of 10 Laboratories on 12 Cements.

tories in the case of concrete). The average values of the ten laboratories (two in the case of concrete) are also plotted for each cement in order to show the deviation of individual cements from the average line.

Figure 5 shows the relations between tensile strength of the briquets and compressive strength of the graded Ottawa sand cubes for each of the four testing periods. Figure 6 shows the relation between tensile strength of the briquets and compressive strength of the standard Ottawa sand cubes. The dotted lines opposite the present specification requirements for tensile strength show the corresponding values for compressive strength of the cubes.

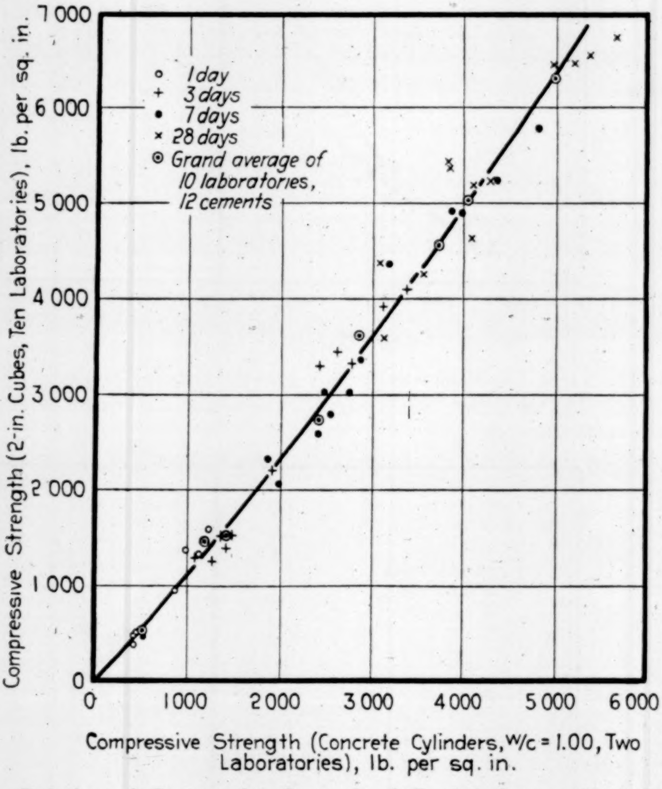


FIG. 7.—Relation of Compressive Strength of Graded Ottawa Sand Cubes to Concrete Strength.

The relations of compressive strength of the concrete to compressive strength of the graded Ottawa sand cubes and of the standard Ottawa sand cubes and to tensile strength of the briquets are shown in

Figs. 7 to 9. These relations are curvilinear but in the case of the concrete and the plastic mortar cubes the lines are not far from rectilinear. The points for the individual cements have not been connected since they fall rather close to the average line. Taking 1000-lb. increments of concrete strength and reading from the curves, Figs. 7 to 9, the following table shows the ratios of the concrete strength to the strengths of the mortar tests:

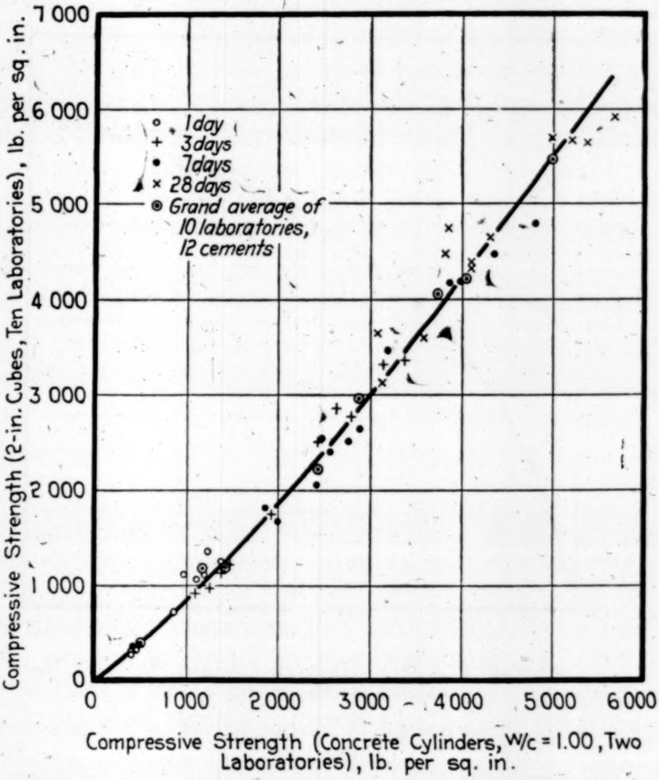


FIG. 8.—Relation of Compressive Strength of Standard Ottawa Sand Cubes to Concrete Strength.

	RATIO CONCRETE STRENGTH TO:		
CONCRETE STRENGTH	BRIQUET STRENGTH	CUBE STRENGTH, GRADED OTTAWA SAND	CUBE STRENGTH, STANDARD OTTAWA SAND
1000	4.25	0.91	1.18
2000	5.88	0.87	1.08
3000	7.32	0.83	1.00
4000	8.69	0.81	0.95
5000	10.20	0.79	0.91

These values demonstrate that the strength of the graded Ottawa sand cubes is a somewhat better indicator of the strength of concrete than is that of the standard Ottawa sand cubes (although the strength of the latter is closer to the actual strength for all values above about 1500 lb. per sq. in.) and a very much better indicator than that of the briquets.

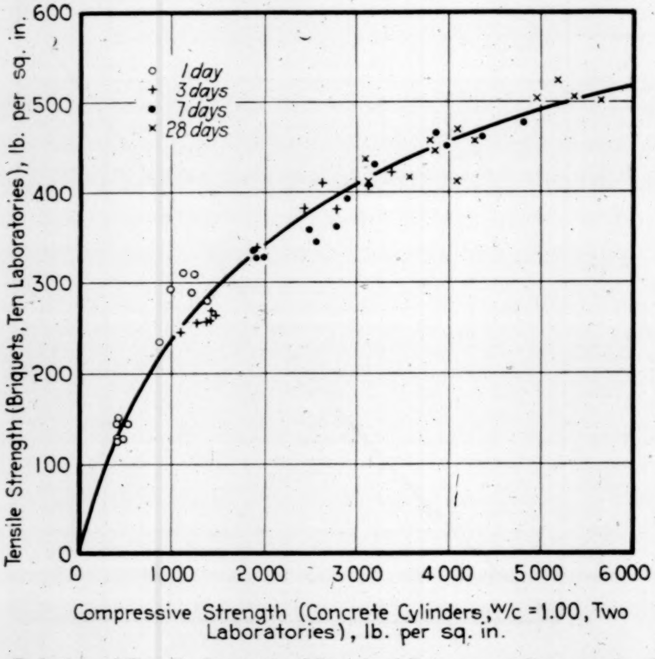


FIG. 9.—Relation of Tensile Strength of Standard Briquets to Compressive Strength of Concrete.

CONCLUSIONS

1. The compressive strength of plastic mortar cubes is a better measure of the compressive strength of concrete than is the tensile strength of standard briquets.

2. The uniformity of strengths of the individual cubes from the same batch of mortar is considerably better than that of the briquets, the grand average percentage mean variations being 3.8 per cent for briquets, 2.4 per cent for graded Ottawa sand cubes, and 2.5 per cent for standard Ottawa sand cubes.

3. The uniformity of strengths of the graded Ottawa sand cubes is somewhat better than that of the standard Ottawa sand cubes.

4. The uniformity of briquet tests made on different days by each laboratory is slightly better than that of the cubes, the grand average percentage mean variations being 3.4 per cent for briquets, 3.6 per cent for graded Ottawa sand cubes, and 3.8 per cent for standard Ottawa sand cubes.

5. The uniformity of the tensile strengths between the ten laboratories is considerably better than that of the compressive cube strengths, the grand average percentage mean variations being 3.8 per cent for briquets, 5.7 per cent for graded Ottawa sand cubes, and 6.9 per cent for standard Ottawa sand cubes.

6. The uniformity between laboratories of both tensile and compressive strength tests of this series is better than the uniformity of previous series reported in 1929 and 1930,[1] as indicated by the grand average percentage mean variations as follows:

	GRAND AVERAGE PERCENTAGE MEAN VARIATIONS		
TEST SERIES	BRIQUETS	GRADED OTTAWA SAND CUBES	STANDARD OTTAWA SAND CUBES
1929 Report	7.6	11.3	....
1930 Report	6.3	8.4	....
Present Series	3.8	5.7	6.9

7. The uniformity of the cube strengths of the laboratories using the hydraulic-type compression testing machine is considerably better than that of the laboratories using the screw-type machine, the grand average percentage mean variations for graded Ottawa sand cubes being 3.3 per cent for laboratories using the hydraulic machines and 5.4 per cent for the laboratories using the screw-type machines. These figures for standard Ottawa sand cubes are 5.2 and 6.4 per cent, respectively.

8. Uniform rates of loading of 3000 and 6000 lb. per sq. in. per minute made practically no difference in strength results of plastic mortar cubes of standard Ottawa sand.

Respectfully submitted on behalf of the working committee,

O. L. MOORE,
Chairman.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 266 (1929); also Vol. 30, Part I, p. 437 (1930).

REPORT OF WORKING COMMITTEE ON VOLUME CHANGE AND SOUNDNESS OF PORTLAND CEMENT

During the past year the Working Committee on Volume Change and Soundness of Portland Cement has been actively at work on the following subjects:

1. Obtaining information on the volume change of neat cement bars when subjected to various temperatures and storage conditions, and

2. Assembling available information on the influence of cement on the volume change characteristics of neat cement, mortar and concrete, under various conditions of storage.

This progress report presents some information obtained in connection with item 1. It has been observed that mortar and concrete specimens cured in steam at pressures above atmospheric pressure develop strength much more rapidly than when moist cured at normal temperatures. It has been noted also that the shrinkage of mortar and concrete is greatly reduced by high pressure steam curing. Under certain conditions of temperature and pressure neat cement specimens expand during steam curing; under other conditions they contract. On the basis of the foregoing information it was thought possible that some relationship existed between the expansion of neat cement specimens during high pressure steam curing and the shrinkage which takes place upon drying after moist curing at 70 F. (21 C.).

In order to ascertain whether such a relationship existed, a series of tests was conducted in the Research Laboratory of the Portland Cement Association in which comparison was made of the volume changes of neat cement bars steam cured at different temperatures with those of similar bars moist cured for 7 and 28 days and then air dried to equilibrium. The details of this study follow:

DETAILS OF TESTS

Specimens.—Neat cement bars 1 in. square having an effective gage length of 10 in. between stainless steel screws cast in the bars at the ends were used. The bars were made with neat cement of a plastic mix with a water-cement ratio of 2.9 gal. per sack of cement (25.6 per cent water by weight).

Cement.—Sixteen commercial cements were used in making the bar specimens. Twelve of these cements were the same as those

TABLE I.—OXIDE ANALYSES AND COMPUTED COMPOSITION OF CEMENTS.

$C_3S = 3CaO \cdot SiO_2$ $C_3A = 3CaO \cdot Al_2O_3$
$C_2S = 2CaO \cdot SiO_2$ $C_4AF = 4CaO \cdot Al_2O_3 \cdot Fe_2O_3$

Cement	Oxide Analysis, percentage by weight						Loss on Ignition, per cent	Insoluble Residue, per cent	Computed Compound Composition Calculated to Clinker Basis, per cent				
	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	SO_3			C_3S	C_2S	C_3A	C_4AF	MgO
NORMAL PORTLAND CEMENTS													
No. 1	20.91	3.00	5.20	63.69	3.02	1.61	1.58	0.19	60	18	9	10	3.2
No. 2	21.21	2.57	5.26	63.52	4.20	1.52	0.88	0.12	56	21	10	8	4.4
No. 3	21.13	3.02	3.96	65.05	3.20	1.48	1.36	0.19	72	9	6	10	3.3
No. 4	20.98	2.98	5.65	63.91	2.14	1.34	1.83	0.08	58	20	11	10	2.2
No. 5	21.00	2.31	6.12	64.44	2.08	1.52	1.42	0.16	57	21	13	8	2.2
No. 6	20.32	3.31	5.64	64.78	2.50	1.14	1.49	0.10	66	11	10	11	2.6
No. 7	20.45	4.16	6.28	64.42	1.32	1.48	1.15	0.20	57	18	10	13	1.4
No. 13	20.61	3.79	6.21	62.83	2.33	2.10	0.95	0.20	47	27	11	12	2.4
No. 14	21.15	2.79	5.88	64.05	1.91	1.93	1.41	0.12	53	25	11	9	2.0
No. 15	21.59	3.21	5.47	61.98	4.07	1.72	0.85	0.08	44	32	9	10	4.3
No. 16	21.13	1.85	6.24	64.05	2.77	1.87	1.53	0.13	52	25	14	6	2.9
HIGH-EARLY-STRENGTH CEMENTS													
No. 8	19.91	4.30	5.99	64.03	1.47	2.46	1.18	0.20	59	16	9	14	1.6
No. 9	19.87	2.76	6.05	65.35	1.40	2.34	1.73	0.27	68	9	12	9	1.5
No. 10	19.63	3.55	6.33	63.13	2.44	2.37	1.42	0.19	57	17	12	12	2.6
No. 11[a]	20.34	2.75	5.11	64.93	1.28	2.09	1.96	0.18	68	12	10	9	1.4
No. 12	19.74	2.25	5.52	65.81	2.03	2.17	1.22	0.12	76	3	12	7	2.1

[a] Chlorine content 0.68 per cent.

TABLE II.—RESULTS OF FINENESS TESTS OF CEMENTS.

Cement	Fineness, Cumulative Percentage Finer Than					Surface Area, sq. cm. per gram
	Air Analyzer				No. 200 Sieve	
	11 µ	21 µ	31 µ	44 µ	95 µ	
NORMAL PORTLAND CEMENTS						
No. 1	27.8	44.6	61.8	71.0	92.6	1520
No. 2	27.2	45.3	66.2	76.3	95.1	1530
No. 3	43.4	66.2	84.0	90.3	98.4	2130
No. 4	36.0	54.0	73.0	81.7	97.8	1830
No. 5	27.2	42.2	59.9	68.5	88.6	1470
No. 6	31.4	48.1	68.5	77.9	96.1	1660
No. 7	31.2	44.4	62.0	70.8	91.8	1600
No. 13	25.8	42.3	61.3	71.7	95.0	1460
No. 14	26.0	40.1	56.9	62.4	89.8	1410
No. 15	25.2	41.9	58.9	69.7	92.4	1420
No. 16	29.8	45.7	62.8	71.9	93.9	1580
HIGH-EARLY-STRENGTH CEMENTS						
No. 8	45.9	68.6	88.6	94.2	99.6	2230
No. 9	42.6	61.1	79.4	87.6	98.7	2070
No. 10	48.0	72.9	91.1	97.0	99.7	2320
No. 11[a]	39.2	61.3	83.3	91.2	99.4	2000
No. 12	39.0	60.2	78.7	85.6	98.0	1970

[a] Chlorine content 0.68 per cent.

used by the Working Committee on Plastic Mortar Tests for Portland Cement of Committee C-1 in its current investigation, described in the accompanying report, with 2-in. plastic mortar cubes and standard briquets. The four remaining cements were the brands used regularly by the Research Laboratory in its mixture of "Laboratory" cement. Calculated compound compositions and finenesses (specific surface by air analyzer) are shown in Tables I and II.

Curing.—Comparable bars were made with each cement for tests under five different conditions.

Three sets of bars were moist-cured for 24 hr. at 70 F. (21 C.) then weighed and measured for length and placed in saturated steam at 212, 250, 300 and 350 F. (100, 121, 149 and 177 C.) for 24 hr., then cooled to 70 F. (21 C.) and again weighed and measured for length. The difference in length before and after steaming was taken as the expansion.

One of the remaining two sets of bars was moist-cured at 70 F. (21 C.) for 7 days and the other set for 28 days. Both sets of bars were cured for the first 24 hr. in the moist room and then in water at 70 F. (21 C.) for the balance of the moist curing period. The expansion during the moist curing period was based on measurements made at the age of 24 hr. At the end of the moist curing period both sets of bars were dried, in a room maintained at about 70 F. (21 C.) and 35 per cent relative humidity, and volume change measurements made. A condition of equilibrium is indicated.

RESULTS OF TESTS

The curves in Fig. 1 compare the expansions of the different cements when steamed at various temperatures with their expansions when moist cured for 7 and 28 days and with their contractions during subsequent drying to equilibrium in air at approximately 35 per cent relative humidity.

For convenience of comparison, curve *A* shows the different cements arranged in the order of increasing expansion when steamed at 212 F. (100 C.) The data for the other curves conform with the order established by curve *A*.

Comparison of curves *A*, *B*, *C* and *D* shows the marked influence of temperature of steaming on the measured volume changes of the bars. Some of the cements which showed low expansion when steamed at 212 F. (100 C.) showed relatively high expansion when steamed at 350 F. (177 C.) and *vice versa*. In general, there does not appear to be any consistent relationship between the volume change of the cements when steamed at one temperature and their volume changes when steamed at another temperature. It is interesting to note that the expansion of bars steamed at 250 and 300 F. (121 and 149 C.) was generally lower than when steamed at 212 F. (100 C.).

Comparison of curves *A*, *B*, *C* and *D* with curves *E* and *F* show no apparent relation between the expansion of a cement steamed at 212, 250, 300 or 350 F. (100, 121, 149 or 177 C.) and the expansion of the same cement during moist-curing for 7 or 28 days.

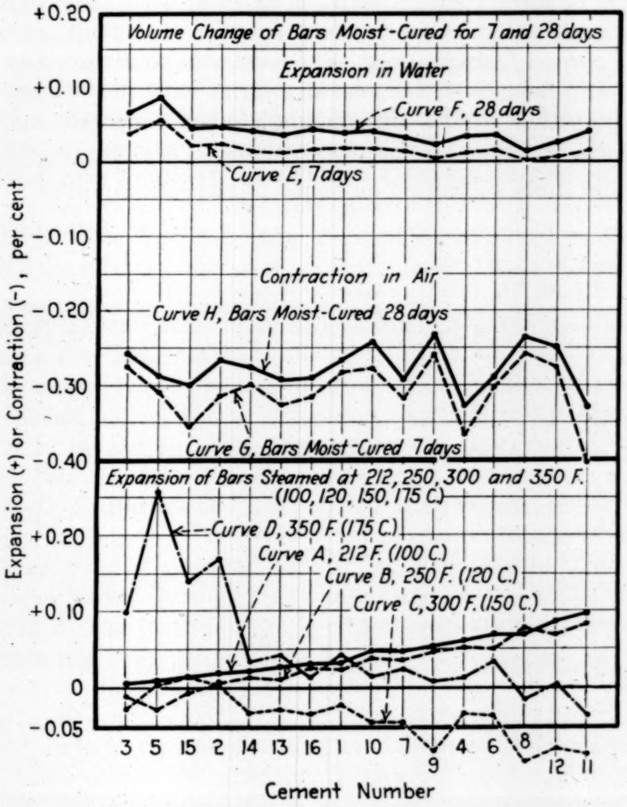


Fig. 1.—Comparison of the Expansion of Neat Cement Bars Steamed at 212, 250, 300 and 350 F. (100, 121, 149 and 177 C.) with the Volume Change Characteristics of Similar Bars Moist Cured for 7 and 28 Days and Subsequently Dried in Air.

Comparison of curves *A*, *B*, *C* and *D* with curves *G* and *H* also fails to show a relation between the expansion of a cement steamed at 212, 250, 300 or 350 F. (100, 121, 149 or 177 C.) and the contraction of the same cement in drying to approximate equilibrium in air at 35 per cent relative humidity after moist-curing for either 7 or 28 days.

CONCLUDING REMARKS

On the basis of the foregoing results it does not appear that the expansion of these cements when steamed at early ages serves as an index of their volume change characteristics when moist cured or air dried at normal temperatures. It is probable that the effect of composition and fineness of the cements varies with the temperatures of curing. Further studies are contemplated in which the variables of composition and fineness will be controlled.

Respectfully submitted on behalf of the subcommittee,

H. F. GONNERMAN,
Chairman.

REPORT OF SUBCOMMITTEE ON CEMENT REFERENCE LABORATORY

(For Period March 1, 1933 to March 31, 1934.)

The Cement Reference Laboratory completed in November the third inspection tour of cement testing laboratories. Shortly thereafter announcement was made of plans for the fourth tour which, according to requests thus far received, will include 217 laboratories distributed over 47 states. In Table I these laboratories are grouped according to laboratory classification and also with respect to prior inspection. The decrease from the number involved in the second and third tours is probably partly due to the fact that some laboratories have been closed. The number of interested State Highway laboratories fluctuates because of occasional changes in the number of their various branch laboratories.

There were made 124 laboratory inspections, four of which form a part of the current fourth inspection tour which was begun in the latter part of March. Two inspectors are now operating in the Pennsylvania district.

The U. S. Bureau of Public Roads continues to require Cement Reference Laboratory inspection in all laboratories which make acceptance tests of portland cement for Federal Aid road projects. There were issued to the proper interested officials, chiefly Federal and State highway officials, 74 copies of inspection reports covering 67 laboratories.

Recently the laboratory has studied the accumulated field inspection data with the thought of securing such comparisons as might indicate to what extent improvements in methods and conditions were taking place during the progress of the work. Inspectors' reports show a decided improvement in apparatus and methods in general, but it is not easy to present detailed comparisons of the data of the various inspection tours. However, some progress has been made and in Tables II and III there are presented certain comparative data relating to the apparatus used in the standard tests of cement, without regard to the percentage of laboratories having the accepted apparatus. Table II summarizes the quantities tested and percentages approved. In Table III there are shown the percentages of satisfactory apparatus present in the groups of laboratories formed on the basis of prior laboratory inspections.

Table I.—Classification of Laboratories Availing Themselves of Field Inspection Service.

Interest	Number of Laboratories Inspected					Laboratories to Be Inspected	
	First Tour	Second Tour		Third Tour		Fourth Tour	
	Total, No Prior Inspection	Total	No Prior Inspection	Total	No Prior Inspection	Total	No Prior Inspection
Cement producers	99	108	34	104	12	94	0
Commercial testing	45	48	20	30	7	36	1
State highway	25	65	41	53	4	60	2
Schools	21	27	21	20	7	15	6
Municipal	11	10	5	9	2	4	0
Miscellaneous	7	7	1	8	2	8	3
Total	208	265	122	224	34	217	12

Table II.—Summary of Apparatus Tested.

Apparatus	First Tour		Second Tour		Third Tour	
	Pieces Tested	Percentage Approved	Pieces Tested	Percentage Approved	Pieces Tested	Percentage Approved
Steam chests	201	48	250	63	211	78
Balances for mixes	266	74	347	68	282	86
Balances for fineness	222	33	260	49	213	76
Tension machines	217	43	260	62	223	80
Vicat apparatus	251	30	309	51	265	80[c]
Gillmore needles (pairs)	262	58[a]	317	61	269	89[c]
Briquet molds	7 764	67	10 643	80[b]	9 188	92[c]
Glass graduates	477	84	594	92	580	94
Weights for mixes	2 951	97	3 721	93	3 053	98
Weights for fineness	1 553	95	2 305	95	2 753	98
Total pieces	14 164	—	19 006	—	17 037	—
Average of percentages		63		71		87

[a] Before requirements were made more stringent 62 of 64 sets were approved.
[b] Method of test made less stringent during second tour.
[c] Change in tolerances during early part of tour.

Table III.—Percentages of Apparatus Approved in Each Group of Laboratories, when Laboratories Are Grouped According to the Number of Prior Inspections They Have Had.

Apparatus	First Tour	Second Tour		Third Tour		
	No Prior Laboratory Inspection, per cent	No Prior Laboratory Inspection, per cent	One Prior Laboratory Inspection, per cent	No Prior Laboratory Inspection, per cent	One Prior Laboratory Inspection, per cent	Two Prior Laboratory Inspections, per cent
Steam chests	48	54	70	57	71	89
Balances for mixes	74	59	77	77	87	93
Balances for fineness	33	25	70	56	70	88
Tensile machines	43	44	74	55	80	89
Vicat apparatus	30	46	56	77	73	87
Gillmore needles (pairs)	58	59	62	76	86	96
Briquet molds	67	74	86	88	93	91
Glass graduates	84	91	92	98	94	92
Weights for mixes	97	92	95	98	97	99
Weights for fineness	95	92	96	97	98	99
Average of percentages	63	64	78	78	85	92

It is proposed to make more detailed study of these same data, but an examination of Tables II and III serves to give some fair idea of the status of apparatus. Table II indicates a steady, although not so desirably rapid, improvement in apparatus in general. Table III indicates an improvement along with the progress of the work. However, it is noticeable that the higher average of percentages of approved apparatus in both the second and third tours is in the groups of laboratories which have availed themselves of all of the preceding inspection services. It is also interesting to note that in both the second and third tours the average percentage of satisfactory apparatus is decidedly relatively low for the laboratories inspected for the first time, indicating that specifications and manuals alone are not so efficacious as when they are supplemented by the personal services of a critical inspector.

The wide-spread interest in the Wagner turbidimeter,[1] which instrument was developed at the Reference Laboratory, hastened the demand for a satisfactory method for the standardization of this relatively new instrument which is now in use in many laboratories. Considerable study has been given to this question of standardization and it is hoped that the series of cooperative tests about to be undertaken by a group of interested laboratories will indicate as satisfactory a method recently suggested by the Reference Laboratory.

The Reference Laboratory, in cooperation with the Working Committee on Fineness of Committee C-1, prepared and distributed samples of four cements for use in the second series of cooperative sub-sieve fineness tests by a large number of laboratories.

The Reference Laboratory has continued to receive numerous inquiries relative to test methods and apparatus.

In cooperation with the Working Committee on Plastic Mortar Tests for Portland Cement, the laboratory completed its assigned portion of the cooperative study of a proposed plastic mortar compressive strength test and also obtained some additional data on the effects of variations in the rate of loading.

Respectfully submitted on behalf of the subcommittee,

C. F. CONN,
Chairman.

---

[1] L. A. Wagner, "A Rapid Method for the Determination of the Specific Surface of Portland Cement," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 553 (1933).

REPORT OF COMMITTEE C-3
ON
BRICK

Committee C-3 on Brick has held two meetings in Washington, D. C., since the submission of its report in 1931, one on May 26, 1933, and the other on March 8, 1934, the latter in conjunction with the Spring Group Meetings of A.S.T.M. Committees. During the year many of the subcommittees have been reorganized and in several cases, new chairmen have been appointed.

In order to have all three brick specifications under the jurisdiction of Committee C-3 substantially identical as to physical properties and test requirements, Subcommittee VII on Concrete Brick (W. G. Kaiser, chairman) recommended to the committee revisions of the Tentative Specifications for Concrete Building Brick (C 55 - 28 T). These revisions were presented to the Society through Committee E-10 on Standards on March 8, 1933,[1] and the specifications in their revised form were accepted for publication as tentative and appear in the 1933 *Proceedings*,[2] the A.S.T.M. designation now being C 55 - 33 T.

The committee now believes that these specifications should be adopted as standard and accordingly recommends that they be approved for reference to letter ballot of the Society for adoption. This recommendation has been submitted to letter ballot of the committee, which consists of 37 members; 24 members returned their ballots, of whom 20 have voted affirmatively, none negatively, and 4 marked their ballots "not voting."

At present the committee has no definite recommendations for revisions of any of its specifications or methods of test. However, several suggested changes have been proposed and at the March meeting it was voted to instruct Subcommittee V on Methods of Testing (F. B. Lysle, chairman) to revise the compressive and transverse tests of brick specified in the Standard Methods of Testing Brick (Compression, Flexure, Absorption) (C 67 - 31). Two suggestions for the revision of these methods have been referred to the subcommittee.

---

[1] In submitting these revised tentative specifications to Committee E-10 on Standards, Committee C-3 reported results of the letter ballot vote as follows: Of a total membership of 39, 34 members returned their ballots, of whom 33 voted affirmatively and none negatively.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 665 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 312.

Subcommittee VIII on Clay Building Brick (J. A. Pugh, chairman) has been instructed to consider the revision of the Standard Specifications for Building Brick (Made from Clay or Shale) (C 62 – 30) to include weather resistance.

There has been considerable discussion regarding a definition for the term "brick," and during the year an approved definition was referred to this committee by Committee E-8 on Nomenclature and Definitions. A special committee of Committee C-3 has been appointed to confer with Committee C-10 on Hollow Masonry Building Units to review the definition of brick, especial consideration being given to solidity, shape and size.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee, which consists of 37 members; 24 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. T. SHELLEY,
Chairman.

J. W. WHITTEMORE,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Concrete Building Brick were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, page 100.

REPORT OF COMMITTEE C-7
ON
LIME

Committee C-7 on Lime has held two meetings since the presentation of its report in 1932, one on June 23, 1932, in Atlantic City, N. J., and the other on March 7, 1934, in Washington, D. C., the latter during the Spring Group Meeting of A.S.T.M. Committees. At the Washington meeting a number of the subcommittees also met on the day prior to the meeting of the main committee. Action has been taken by the committee on a number of recommendations affecting the standards under its jurisdiction. These are discussed further in this report. Due to restricted budgets for travel and research, the committee has undertaken only a limited amount of work. The membership of the committee now totals 41, classified as 19 producer, 8 consumer and 14 general interest members.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Revision of Standards:

Standard Specifications for Quicklime for Structural Purposes (C 5 – 26).[1]—These standard specifications for quicklime have been reviewed and carefully considered by Subcommittee II on Structural Lime (N. G. Hough, chairman) and it is now proposed to revise them to include all classes of quicklime and to add also a provision that quicklime for use in plaster shall test sound. It is further proposed to eliminate from the specifications the detailed descriptions of the test methods and to publish these collectively along with the present methods of chemical analysis. The changes have been incorporated in the proposed revised specifications appended hereto[2] which the committee recommends for publication as a tentative revision of the present standard specifications.

Standard Specifications for Hydrated Lime for Structural Purposes (C 6 – 31).[3]—The specifications for hydrated lime have also been carefully reviewed by Subcommittee II and it is proposed to incorporate in these specifications new requirements for soundness and likewise to eliminate the detailed methods of testing. These changes have been incorporated in the proposed revised specifications appended hereto[1] which the committee recommends for publication as a tentative revision of the present standard specifications.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 24.

[2] See p. 749.—Ed.

[3] 1933 Book of A.S.T.M. Standards, Part II, p. 27.

Standard Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (C 25 - 29).[2]—The proposal referred to above to publish the physical test methods for quicklime and hydrated lime collectively in the same standard as the chemical tests has been considered by Subcommittee V on Methods of Test of Lime and Lime Products (L. S. Wells, chairman) and it is considered desirable to issue the methods in this form. Consideration has also been given to the autoclave method of test for soundness of lime and it is now proposed to include this test with the physical test methods. The various physical testing procedures have been incorporated in the Proposed Tentative Methods of Physical Test for Limestone, Quicklime and Hydrated Lime, appended hereto[3] which the committee recommends for publication as tentative and which are intended eventually to be added when adopted to the Standard Methods C 25.

II. Withdrawal of Tentative Revision of Standard:

In view of the revisions that are being proposed in the Standard Specifications for Hydrated Lime for Structural Purposes (C 6 - 31) covering the deletion of all methods of test, as explained earlier in this report, the committee recommends that the tentative revision[4] of Section 12 of these specifications, proposed in 1925, and the tentative revision[4] of Section 13, proposed in 1928, be withdrawn. The revisions consisted in a change in the method of controlling the consistency of lime putty and in the inclusion of additional directions for preparing the putty.

The above recommendations have been submitted to letter ballot of the committee, which consists of 41 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE REVISION OF STANDARDS			
Specifications for Quicklime for Structural Purposes (C 5 - 26)	16	2	1
Specifications for Hydrated Lime for Structural Purposes (C 6 - 31)	16	2	1
Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (C 25 - 29)	13	1	5
II. WITHDRAWAL OF TENTATIVE REVISION OF STANDARD			
Specifications for Hydrated Lime for Structural Purposes (C 6 - 31)	16	1	2

---

[1] See p. 752.—ED.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 49.

[3] See p. 754.—ED.

[4] *Proceedings,* Am. Soc. Testing Mats., Vol. 33, Part I, p. 1031 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 1069.

Committee C-7 has given consideration to the Tentative Specifications for Sand for Use in Lime Plaster (C 66 – 31 T) which it believes might well be adopted as standard. On the recommendation of the committee officers, however, this proposal has been deferred since a special conference committee was authorized during the year to review the two existing specifications of the Society for sand for plastering; namely, the Tentative Specifications C 66 – 31 T just mentioned, and the Standard Specifications for Sand for Use in Gypsum Plaster (C 35 – 30). This special committee, which is composed of representatives of Committee C-11 on Gypsum, Sectional Committee A42 on Specifications for Plastering and Committee C-7, is to give consideration to a proposed consolidation of these existing specifications.

Subcommittee X on Hydraulic Lime (W. E. Carson, chairman) submitted to the committee at its meeting in Washington, proposed tentative specifications for "eminently" hydraulic lime. A number of suggestions for improvement of these specifications were received from members of the committee subsequent to the meeting, all of which were referred to Subcommittee X. These specifications have accordingly been returned to the subcommittee, without prejudice, for further study.

The election of officers resulted in the selection of the following for the ensuing term of two years:

Chairman	James R. Withrow
Vice-Chairman	E. E. Eakins
Vice-Chairman	L. S. Wells
Secretary	Lee S. Trainor

This report has been submitted to letter ballot of the committee, which consists of 41 members; 27 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

JAMES R. WITHROW,
Chairman.

LEE S. TRAINOR,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Quicklime for Structural Purposes, for Hydrated Lime for Structural Purposes, and Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime, in the form of new tentative specifications and methods of physical testing, were accepted for publication as tentative and appear on pages 749, 752 and 754, respectively.

The withdrawal of the tentative revision of the Standard Specifications for Hydrated Lime for Structural Purposes was approved.

REPORT OF COMMITTEE C-8

ON

REFRACTORIES

Committee C-8 on Refractories held two meetings during the year; in Pittsburgh, Pa., on September 22, 1933, and in Cincinnati, Ohio, on February 12, 1934, the latter in conjunction with the annual meeting of the American Ceramic Society.

The committee has been very active during the past year, both in revising some of its present test methods and in developing new ones. Considerable effort has been expended on developing suitable specifications for certain types of refractories. The Refractories Manual, issued in 1932, has been so favorably received that the present stock of the original issue is exhausted. The committee is planning to make a number of revisions and additions to the Manual and to have the Society publish a new edition.

RECOMMENDATIONS AFFECTING STANDARDS

The recommendations of the committee regarding standards and tentative standards under its jurisdiction are summarized below, together with the analysis of the letter ballot on each item.

I. Proposed Tentative Standards:

Proposed Tentative Specifications for Ground Fire Clay.—The material used as mortar in laying up fire brick in furnace construction exerts considerable influence on the life of the brickwork. In order to protect the consumer and at the same time protect the manufacturer from illogical specifications, Subcommittee I on Tests and Specifications has developed proposed Tentative Specifications for Ground Fire Clay. Committee C-8 accordingly recommends that these specifications be accepted for publication as tentative as appended hereto.[1]

Proposed Tentative Specifications for Refractories for Construction of Incinerators.—A number of municipalities are now actually building or are proposing to build incinerators for the disposal of garbage and rubbish. The service on the refractories in these furnaces is rather severe and in order to assist city officials and incinerator builders in the selection of the refractories by adequate and logical specifications, Subcommittee I has developed proposed Tentative Specifications for Refractories for Construction of Incinerators. Committee C-8 accordingly recommends that these specifications be accepted for publication as tentative as appended hereto.[1]

---

[1] See p. 780.—ED.

Proposed Tentative Method of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling.—It has been recognized for several years that the water-dip spalling test described in the Tentative Method of Control Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (C 38 – 33 T)[2] did not predict the behavior of a refractory brick in actual service. In many furnaces thermal and structural spalling are important causes of failure and refractories technologists have searched diligently for a method that would forecast the performance of the brick in service. The so-called panel spalling test developed by Subcommittee II on Research seems to give the desired information, at least for several service conditions. The committee accordingly recommends that the proposed Tentative Method of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling, appended hereto,[3] be accepted for publication as tentative to replace the present Tentative Method C 38 – 33 T which is recommended to be withdrawn.

Proposed Tentative Method of Panel Test for Resistance to Thermal and Structural Spalling of Fire-Clay Brick for Stationary Boilers and Malleable Iron Furnace Bungs.—The panel spalling test seems to give results comparable with those obtained in service in stationary boiler furnaces and malleable iron furnace bungs, and the committee accordingly recommends that the proposed method of test, appended hereto,[4] be accepted for publication as tentative.

Proposed Tentative Method of Chemical Analysis of Magnesite Refractories.—The committee recommends that the proposed Tentative Method of Chemical Analysis of Magnesite Refractories, appended hereto,[5] be accepted for publication as tentative, to be incorporated when adopted in the Standard Methods of Ultimate Chemical Analysis of Refractory Materials (C 18 – 21).

Proposed Tentative Symbols for Heat Transmission.—The committee believes that the symbols for heat transmission, which were prepared jointly by the Committee on Heat Transmission of the National Research Council and the Subcommittee on Symbols for

---

[1] See p. 782.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 689 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 371.

[3] See p. 796.—ED.

[4] See p. 804.—ED.

[5] See p. 784.—ED.

Heat and Thermodynamics of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations, and approved by the American Standards Association in 1931 as American Tentative Standard, are more valuable to consumers and manufacturers of, and others interested in, refractory materials than the present A.S.T.M. Tentative Definitions of Terms Relating to Heat Transmission of Refractories (C 71 – 31 T). The committee therefore recommends that the proposed Tentative Symbols for Heat Transmission, appended hereto,[1] be accepted for publication as tentative.

Proposed Tentative Definitions of Terms Relating to Refractories.—The committee recommends that the following definitions be accepted for publication as tentative to be subsequently incorporated in the Standard Definitions of Terms Relating to Refractories (C 71 – 31) when adopted as standard:

Silica Fire Clay.—A refractory mortar consisting of a finely ground mixture of quartzite, silica brick, and fire clay of various proportions.

NOTE.—Sometimes called silica cement by the trade.

Ground Fire Clay.—Fire clay or a mixture of fire clays which have been subjected to no treatment other than grinding or weathering, or both.

High-Temperature Bonding Mortar.—A mixture of refractory materials (such as fire clay, quartzite, chrome ore, magnesite, diaspore, or sillimanite minerals) either raw or calcined, to which other materials, not classified as refractories, have been added for the purpose of increasing the plasticity, giving air-setting properties, or lowering the temperature at which the bond develops.

II. Proposed Revision of Tentative Standard:

Tentative Methods of Testing High-Temperature Heat Insulation (Compression, Flexure, Shrinkage) (C 93 – 33 T).[2]—Subcommittee VI on Heat Transfer and Refractory Insulation has been making a critical study of these test methods and Committee C-8 accordingly recommends that the methods be revised as follows and continued as tentative:

Section 3.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

3. The test specimen shall *preferably* consist of a half-brick measuring [approximately] 4½ by 4½ by 2½ in. *If a specimen having dimensions other than these is used, they shall be reported.*

Section 15.—Change to read as follows by the addition of the italicized words:

15. The test specimen shall preferably be 9 by 4½ by 2½ in. *If a specimen having dimensions other than these is used, they shall be reported.*

---

[1] See p. 807.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 684 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 363.

Section 16.—Change Paragraphs (*b*) and (*c*) to read as follows by the addition of the italicized words and the omission of those in brackets:

(*b*) The test specimen shall be placed in the furnace *preferably* on the 9 by [4½] *2½* in. [surface] *edge, resting on a slab of the same composition whose thickness shall be not less than 1 in.* The *test* specimen shall be protected from direct flame or localized heating from direct contact with furnace parts.

(*c*) The maximum temperature to be used shall depend upon the material. This maximum temperature shall be obtained in not less than 3 hr. The maximum temperature shall be [maintained] *held* for a period of [five] *24* hr. The specimen shall be left in the furnace until the furnace temperature has fallen to at least 500 F. (260 C.).

Section 17.—Add a new paragraph as Paragraph (*a*) to read as follows, lettering the present section as Paragraph (*b*):

17. (*a*) The lineal shrinkage shall be calculated from measurements taken along the three major axes. The shrinkage in length, width, and thickness shall be reported separately. The lineal shrinkage shall be calculated on the basis of each original dimension.

III. Adoption of Tentative Standard as Standard:

The committee recommends the submission of the Tentative Method of Test for Particle Size of Ground Refractory Materials (C 92 – 32 T)[1] to letter ballot of the Society for adoption as standard.[2]

IV. Withdrawal of Tentative Standards:

Tentative Method of Control Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (*C 38 – 33 T*).[3]—In view of the submission to the Society for acceptance as tentative of the proposed Tentative Method of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling, as stated earlier in this report, the committee recommends that the Tentative Method C 38 – 33 T be withdrawn.

Tentative Definitions of Terms Relating to Heat Transmission of Refractories (*C 71 – 31 T*).[4]—In view of the fact that the committee is now submitting for acceptance as tentative the proposed Tentative Symbols for Heat Transmission, as stated earlier in this report, the committee recommends that the Tentative Definitions C 71 – 31 T be withdrawn.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 721 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 368.

[2] This recommendation was not accepted by the Society at the annual meeting, see Editorial Note, p. 375.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 689 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 371.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 779 (1931); also 1933 Book of A.S.T.M. Tentative Standards, p. 373.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 35 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARDS			
Specifications for Ground Fire Clay	30	0	2
Specifications for Refractories for Construction of Incinerators	25	2	5
Method of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling (C 38 – 34 T)[a]	26	4	1
Method of Panel Test for Resistance to Thermal and Structural Spalling of Fire-Clay Brick for Stationary Boilers and Malleable Iron Furnace Bungs[b]	25	3	3
Method of Chemical Analysis of Magnesite Refractories (C 18 – 34 T)	25	0	5
Symbols for Heat Transmission	32	0	0
Definitions of Terms Relating to Refractories (C 71 – 34 T):			
Definition of Silica Fire Clay	29	0	2
Definition of Ground Fire Clay	29	0	2
Definition of High-Temperature Bonding Mortar	28	2	2
II. REVISION OF TENTATIVE STANDARD			
Tentative Methods of Testing High-Temperature Heat Insulation (Compression, Flexure, Shrinkage) (C 93 – 33 T)	30	1	1
III. ADOPTION OF TENTATIVE STANDARD			
Tentative Method of Test for Particle Size of Ground Refractory Materials (C 92 – 32 T)	29	0	3
IV. WITHDRAWAL OF TENTATIVE STANDARDS			
Tentative Method of Control Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (C 38 – 33 T)	27	2	2
Tentative Definitions of Terms Relating to Heat Transmission of Refractories (C 71 – 31 T)	31	0	1

[a] The classified vote on the Tentative Method of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling was as follows: Affirmative: 10 producers, 7 consumers, 9 general interests; negative: 1 producer, 1 consumer, 2 general interests; not voting: 1 producer, 0 consumer, 0 general interests.

[b] The classified vote on the Tentative Method of Panel Test for Resistance to Thermal and Structural Spalling of Fire-Clay Brick for Stationary Boilers and Malleable Iron Furnace Bungs was as follows: Affirmative: 10 producers, 6 consumers, 9 general interests; negative: 1 producer, 0 consumer, 2 general interests; not voting: 1 producer, 2 consumers, 0 general interests.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Tests and Specifications (M. E. Holmes, chairman):

Subcommittee I has been active in developing the proposed Specifications for Ground Fire Clay and Specifications for Refractories for Construction of Incinerators which are being submitted for acceptance as tentative, as mentioned earlier in this report. The subcommittee has also conducted voluminous correspondence in reference to constructive criticisms of the standard test methods under the jurisdiction of Committee C-8. The activities of the various sections of Subcommittee I are as follows:

Section on Analysis (L. J. Trostel, chairman).—The National Bureau of Standards has not yet issued the final certificate on the standard chrome ore sample. This will probably be issued within the next few months. An attempt will be made to have the Bureau establish the true FeO content of this material. This section has developed a proposed Method of Chemical Analysis of Magnesite Refractories which is being submitted to the Society for acceptance as tentative, as stated earlier in this report.

Section on Load (R. A. Heindl, chairman).—It is considered advisable to specify some higher temperature for high heat duty brick than that now specified in the Standard Method of Test for Refractory Materials under Load at High Temperature (C 16 – 20). Additional data will be obtained on this subject.

Section on Heat Transfer and Refractory Insulation (R. H. Heilman, chairman).—On account of the vast interest in the subject of refractory insulation this committee has been unusually active in making a critical study of the test methods for this type of product.

Section on Precision and Tolerances (A. E. R. Westman, chairman).—The chairman has been reviewing and simplifying the Manual for Interpretation of Refractory Test Data.

Section on Spalling (M. C. Booze, chairman).—This section has been active in developing proposed Methods of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling, which are being submitted to the Society for acceptance as tentative, as stated earlier in this report.

Section on Temperature (M. E. Holmes, chairman).—There has been so much comment recently regarding the terms, "Pyrometric Cone Equivalent," "fusion point" and "softening point," that Mr. F. A. Harvey has been induced to prepare a discussion on this subject, hoping to clarify the action of heat on refractories. This discussion appears as an Appendix to this report.

Section on Sieves (L. J. Trostel, chairman).—After considerable discussion and correspondence Committee C-8 has voted to retain the reference to the Tyler standard sieves in the Tentative Method of Test for Particle Size of Ground Refractory Materials (C 92 – 32 T). This action was based on the fact that Tyler sieves are used by 96 per cent of manufacturers of refractories and the cost of changing to another series would be almost prohibitive. The Tyler series, except Sieve No. 4, conform to the A.S.T.M. Standard Specifications for Sieves for Testing Purposes (E 11 – 26). Also, the members of Committee C-8 do not favor the micron designation of sieves.

Subcommittee II on Research (S. M. Phelps, chairman):

This subcommittee has been working on a mechanical device to obtain the end point for the spalling loss in the panel spalling test.

Subcommittee III on Nomenclature (A. S. Watts, chairman):

This subcommittee has proposed definitions for "high-temperature bonding mortar," "silica fire clay," and "ground fire clay," which appear earlier in this report, and is now working on a definition for plastic refractories and "grog fire clay."

Subcommittee IV on Industrial Survey (L. C. Hewitt, chairman):

This subcommittee has been investigating refractories for nonferrous metal foundries.

Subcommittee V, Editorial (L. J. Trostel, chairman):

Subcommittee V has been very active during the year in completely revising and improving the text of the forthcoming issue of the Refractories Manual.

The regular election of officers was held at the meeting on February 12, 1934, and the following were elected unanimously to direct the work of the committee for the ensuing two years:

Chairman, R. A. Heindl;
Vice-Chairman, E. H. Van Schoick;
Secretary, C. E. Bales.

This report has been submitted to letter ballot of the committee which consists of 35 members; 34 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

R. A. HEINDL,
Chairman.

C. E. BALES,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Ground Fire Clay, for Refractories for Construction of Incinerators, Methods of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling, Panel Test for Resistance to Thermal and Structural Spalling of Fire-Clay Brick for Stationary Boilers and Malleable Iron Furnace Bungs, Chemical Analysis of Magnesite Refractories, Symbols for Heat Transmission and Definitions of Terms Relating to Refractories were accepted for publication as tentative and appear on pages 780 to 808, inclusive.

The revision of the Tentative Methods of Testing High-Temperature Heat Insulation (Compression, Flexure, Shrinkage) was accepted. The methods in their revised form appear on page 791.

The withdrawal of the Tentative Method of Control Test for Resistance of Fire-Clay Brick to Thermal Spalling Action and Definitions of Terms Relating to Heat Transmission of Refractories was approved.

The recommendation for the adoption as standard of the Tentative Method of Test for Particle Size of Ground Refractory Materials, was referred back to Committee C-8 on Refractories at the annual meeting, see Summary of Proceedings, page 23.

APPENDIX

PYROMETRIC CONE EQUIVALENT *versus* FUSION POINT

A Question of Nomenclature

By F. A. Harvey[1]

The terms "fusion point," and "melting point" or "softening point" have frequently been used in refractory terminology to describe the property which is defined as Pyrometric Cone Equivalent in the A.S.T.M. Standard Definitions of Terms Relating to Refractories (C 71 – 31).[2] The term "fusion point" was almost universally used in refractories standards before the adoption of Pyrometric Cone Equivalent, abbreviated P.C.E. The readiness with which the term P.C.E. has been adopted has been a matter of surprise to the members of the committee who sponsored it; nevertheless, there is some opposition to its use and it is the purpose of this discussion to inquire into the pros and cons of the question. Whether or not the term Pyrometric Cone Equivalent will be maintained is, of course, uncertain. It will depend on whether it defines a distinct property better than some other term.

To the physicist, the term "fusion point" is synonymous with "melting point." Since this statement may be questioned, the following references may be of interest. Preston-Cotter(**1**)[3] in "Theory of Heat," in the chapter on Fusion defines "normal fusion point." He uses the terms "fusion" and "melting" interchangeably in the chapter. Edser(**2**) in "Heat for Advanced Students," heads his discussion "Fusion" and then proceeds to discuss melting point. It should be mentioned that it is usually the "freezing point" which is actually determined. Findlay(**3**) in "The Phase Rule," uses fusion point and melting point interchangeably. Watson(**4**) in "Textbook of Physics," defines melting point, but uses the words "melting" and "fusion" without distinction. Sosman(**5**) in "The Properties of Silica," defines melting point and discusses it under the heading "The Fusion of Crystalline Silica." Ferry(**6**) in "General Physics" defines fusion point or melting point. It is not an unusual experience to look in the index of some book for fusion point and find the section in the text headed "Melting Point."

To the physicist, the term "melting point" has a very precise meaning; it is defined as "the temperature at which crystalline and liquid phases can exist together in equilibrium at a definite (usually atmospheric) pressure." Pure crystalline substances, such as ice, have definite melting points, while noncrystalline substances, such as glass, do not have definite melting points. Substances like glass, when heated to a sufficiently high temperature, soften and pass gradually from the solid to the liquid state. The fusion point of crystalline substances is frequently determined by heating the substance to a temperature above its melting point and allowing it to cool slowly, with thorough stirring, taking temperature readings at ferquent time intervals. In the ideal case, the temperature of the substance will remain constant from the time the substance begins to solidify or crystallize, until all liquid has disappeared. Even pure substances may offer difficulties for determinations made in this manner, if the liquid phase is highly viscous.(5) When the substance is impure or a mixture of several materials, as is the case with practically all refractories, there is no definite melting point. When a refractory mixture, such as flint and plastic clay, is gradually heated, the least refractory fraction of the mixture begins to soften first. As this fraction becomes more fluid, it may act as a lubricant, allowing the more refractory grains or crystals to slide past each other. Complete deformation of a cone made from a refractory material may thus occur at a temperature far below that at which the most refractory fraction of the mix begins to soften. The temperature at which some definite degree of deformation occurs, for example, when the tip of the cone touches the plaque on which it rests, depends also upon the rate at which the cone is heated, the furnace atmosphere, and the degree of fineness to which the sample was ground before forming the cone.

---

[1] **Director of Research, Harbison-Walker Refractories Co., Pittsburgh, Pa.**

[2] **1933 Book of A.S.T.M. Standards, Part II, p. 189.**

[3] The boldface numbers in parentheses refer to the papers given in the list of references appended to this paper, see p. 377.

There is still another fundamental condition to be considered. Most refractories are not in a state of equilibrium. For example, a cone of flint fire clay starts its conversion into mullite and free silica at about 1100 C. and both are acted upon by the iron oxide and alkalies which are present as impurities. These changes are actually going on during the period in which the cone is being heated to determine its P.C.E., melting point, fusion point, or whatever it should be called.

Consider the care which must be exercised in the determination of a point on the liquidus curve by the method devised at the Geophysical Laboratory. After fine grinding, the substance must be melted, cooled, and reground, and this treatment repeated several times before the sample is ready for test.

If it has been established that common refractories have neither a melting point nor a fusion point, as these terms are defined by the old established sciences, are we justified in using either of these terms in a new sense in the field of ceramics? Is it not better to recognize that a new name should be used to describe the phenomenon which we are attempting to measure?

REFERENCES

(1) Thomas Preston, "The Theory of Heat," Second Edition revised by J. R. Cotter, Chapter I, Section I, p. 335, The Macmillan Co., New York City (1904).

(2) Edwin Edser, "Heat for Advanced Students," Chapter VIII, p. 164 (1909).

(3) Alexander Findlay, "The Phase Rule and Its Applications," Third Edition, pp. 25, 30, 70, 146, and 153, Longmans, Green and Co., New York City (1917).

(4) W. Watson, "A Text-Book of Physics," Fourth Edition, p. 244, Longmans, Green and Co., New York City (1903).

(5) R. B. Sosman, "The Properties of Silica," pp. VI, 86, 87, The Chemical Catalog Co., Inc., New York City (1927).

(6) E. S. Ferry, "General Physics," Third Edition, p. 254, John Wiley and Sons, Inc., New York City (1928).

REPORT OF COMMITTEE C-9

ON

CONCRETE AND CONCRETE AGGREGATES

Committee C-9 on Concrete and Concrete Aggregates held one meeting during the year, on March 8, 1934, at Washington, D. C., in connection with the Spring Group Meetings of A.S.T.M. Committees.

The year's activity has culminated in one new tentative specification and one new tentative method of test; and in recommendations for adoption as standard of five tentative specifications.

The following papers prepared by subcommittees are presented as appendices to this report:

"Comparison of Standards for Colorimetric Test for Sand," abstract of an unpublished paper by C. L. Ford, Appendix I, presented by Subcommittee X on Deleterious Substances in Concrete;

"A Study of the Permeability of a Few Integrally Waterproofed Concretes," by W. M. Dunagan and G. C. Ernst, Appendix II, presented by Subcommittee VIII on Permeability Tests of Concrete.

The following new projects have been undertaken by the committee:

Development of a method of making accelerated compression tests of concrete by means of high temperatures;

Development of a method of test of concrete placed by means of vibration;

Value of blended cements in reducing permeability in concrete; and

Studies in evaluation of data.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Standard.—The committee submits for publication as tentative the following specifications:

Proposed Tentative Specifications for Sodium Silicate for Curing Concrete.[1]—These specifications have been prepared by Subcommittee XIII on Curing of Concrete (F. H. Jackson, chairman) in recognition of the need of a quality specification for a material which is already being used as a curing agent for concrete, and are recommended for publication as tentative as appended hereto.[1]

---

[1] See p. 833.—Ed.

II. Adoption of Tentative Standards as Standard.—Committee C-9 recommends that the following tentative specifications,[1] which have been in satisfactory use for three years, be submitted to letter ballot of the Society for adoption as standard:

Tentative Specifications for Curing Portland-Cement Concrete (C 80 – 31 T)

Tentative Specifications for Curing Portland-Cement Concrete Slabs with Bituminous Coverings (C 81 – 31 T)

Tentative Specifications for Curing Portland-Cement Concrete Slabs with Calcium Chloride Admixture (C 82 – 31 T)

Tentative Specifications for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride (C 83 – 31 T)

Tentative Specifications for Curing Portland-Cement Concrete Slabs with Wet Coverings (C 84 – 31 T)

III. Tentative Standards Continued as Tentative.—The following specifications and test methods which have been tentative for three or more years are being continued as tentative, without revision, for the reasons indicated:

Several changes in the Tentative Specifications for Concrete Aggregates (C 33 – 31 T) are under consideration and must be definitely decided upon before presentation to the Society.

The Tentative Laboratory Method of Making Flexure Tests of Concrete Using a Simple Beam with Center Loading (C 78 – 30 T) is being retained as tentative until it can be made to coincide with the method of the American Association of State Highway Officials in view of the fact that the state highway departments are the largest users of the beam test.

The Tentative Method of Routine Analysis of the Cement Content of Hardened Portland Cement Concrete (C 85 – 31 T) and the Tentative Method of Test for Apparent Specific Gravity of Coarse Aggregates in a Saturated Condition (C 86 – 31 T) have had insufficient trial due to the condition of the times.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 58 members, with the following results:

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 756 to 762 (1931); also 1933 Book of A.S.T.M. Tentative Standards, pp. 426 to 432.

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Specifications for Sodium Silicate for Curing Concrete	33	0	0
II. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications for Curing Portland-Cement Concrete (C 80 - 31 T)	44	2	2
Specifications for Curing Portland-Cement Concrete Slabs with Bituminous Coverings (C 81 - 31 T)	35	4	9
Specifications for Curing Portland-Cement Concrete Slabs with Calcium Chloride Admixture (C 82 - 31 T)[a]	36	5	7
Specifications for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride (C 83 - 31 T)[b]	35	6	7
Specifications for Curing Portland-Cement Concrete Slabs with Wet Coverings (C 84 - 31 T)	46	1	1

---

[a] The classified vote on the Tentative Specifications for Curing Portland-Cement Concrete Slabs with Calcium Chloride Admixture was as follows: Affirmative: 7 producers, 17 consumers, 12 general interests; negative: 1 producer, 1 consumer, 3 general interests.

[b] The classified vote on the Tentative Specifications for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride was as follows: Affirmative: 5 producers, 16 consumers, 14 general interests; negative: 1 producer, 3 consumers, 2 general interests.

This report has been submitted to letter ballot of the committee, which consists of 58 members; 48 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

R. W. CRUM,
Chairman.

R. R. LITEHISER,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Sodium Silicate for Curing Concrete, as modified on the floor of the annual meeting, see Summary of Proceedings, page 25, were accepted for publication as tentative and appear on page 833.

The recommendation for the publication of the proposed Tentative Method of Test for Coal and Lignite in Sand, which appeared in the report as preprinted, was withdrawn at the annual meeting, see Summary of Proceedings, page 25.

The Tentative Specifications for Curing Portland-Cement Concrete, for Curing Portland-Cement Concrete Slabs with Bituminous Coverings, for Curing Portland-Cement Concrete Slabs with Calcium Chloride Admixture, for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride, and for Curing Portland-Cement Concrete Slabs with Wet Coverings were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 102 to 108, inclusive.

APPENDIX I

COMPARISON OF STANDARDS FOR COLORIMETRIC TEST FOR SAND

Abstract of Unpublished Paper By C. L. Ford, Assistant Chemist, Research Laboratory of the Portland Cement Assn., Chicago, Ill.

Questions arising from time to time regarding the applicability and limitations of the Abrams-Harder Colorimetric Test[1] and the A.S.T.M. Standard Method of Test for Organic Impurities in Sands for Concrete (C 40 - 33),[2] led to a quantitative study of results obtained with tannic acids from six different sources. Study was also made of the colors developed by a natural sand containing organic matter and treated with 3 per cent sodium hydroxide solution, the sand being mixed in different proportions with a sand free from organic matter.

The methods used were those indicated in the above references, with some modifications that would give checks on the quantitative interpretation of the colors developed. Observations of the intensity of the colors were made at 3, 6, 24 and 48 hr. after preparation of the solutions.

In the study of the various tannic acids it was found that very considerable differences in color were obtained. The differences were most marked at the 6-hr. period, all showing decided fading at the 24-hr. period. This may be explained in part by the greater clarity of the solutions at the 24-hr. period. At 48 hr. all solutions had faded to a small fraction of their early value. It was also noted, particularly in the early periods, that the color values obtained with different amounts of the standard tannic acid solutions were not in agreement.

In the study of the colors produced by the natural sand combinations, it was found that the color values were quite erratic. In most cases the color with a given amount of filtered solution was not proportional to that obtained by using a different amount of the same solution. It was also found that the color value with different proportions of the contaminated sand was not proportional to the amount of this sand.

It should be noted that the foregoing results do not necessarily disqualify the test. They simply bring out the fact that the intensity of the color is not a quantitative indication of the amount of organic material present; but since the color value means nothing until it is correlated with strength tests of the sand in question, this lack of proportionality is not important.

---

[1] See "Suggested Colorimetric Tests for Organic Impurities in Sand," Appendix II, Report of Committee C-9 on Concrete and Concrete Aggregates, *Proceedings*, Am. Soc. Testing Mats., Vol. XVII, Part I, p. 327 (1917).

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 236.

CONCLUSIONS

The color values obtained from tannic acid, as used in the colorimetric test of sand, appear to vary considerably depending on the brand and grade of tannic acid, the relative amounts of the constituents, and the time of standing before comparison is made. Similarly, the color value for a given sand based on the sodium tannate standard is subject to the same variable factors.

The first of the above factors applies whether the test is performed in accordance with the A.S.T.M. standard or according to the Abrams-Harder quantitative method. The second applies only to the latter method, while the third is eliminated if definite time is adhered to. This is fixed at 24 hr. in the A.S.T.M. method.

It is the intent of the A.S.T.M. Method C 40 not to prescribe a hard and fast rule for accepting or rejecting concrete sands, but rather to serve as a warning that sands which produce dark colors should be subjected to other tests to determine their suitability for use in concrete. The results of this investigation serve to further emphasize the discretion which must be used in interpreting the results of the colorimetric test.

APPENDIX II

A STUDY OF THE PERMEABILITY OF A FEW INTEGRALLY WATERPROOFED CONCRETES

By W. M. Dunagan[1] and G. C. Ernst[1]

The effect of certain integral waterproofing materials upon the water-tightness of portland cement concrete was studied at the Materials Laboratory of the College of Engineering, Iowa State College, as one phase of a series of permeability studies. In this phase of the investigation the data obtained relative to the water-tightness, strength, absorption and void content were observed so that they might be of value in the entire series of studies; the results were of such uniform and consistent nature that they are of interest to all concerned with the use of similar materials as waterproofing ingredients in concrete.

Waterproofing Materials

The waterproofing materials chosen for study were those concerning which information had been requested by users in the State of Iowa. They are designated in this paper as follows:

1.	Admixture A	A diatomaceous silica (4 per cent by weight of cement)
2.	Admixture B	A clay (bentonite) (8 per cent by weight of cement)
3.	Special cement C	A portland cement containing a water repellent
4.	Admixture D	Hydrated lime (5 per cent by weight of cement)
5.	Special cement E	A portland cement containing a water repellent
6.	Special cement F	A high-early-strength cement

Methods and Apparatus

Permeability Test:

Permeability was measured by the rate of flow of water under pressure of 50 lb. through concrete disks; these specimens were 1½ in. thick and 6 in. in diameter, held during test in the unit shown in Fig. 1. Five units were in operation simultaneously testing specimens cast at the same time. These units were satisfactory with respect to ease of handling, sealing of the specimen and for preserving the specimen for absorption records or later retesting.

Aggregates:

The cement used in the plain concrete and admixture mixes was a blend of five commercial portland cements. The special cements were purchased on the open market.

The sand was a well-graded sand with a fineness modulus of 3.12 and a rather low silt content of 0.8 per cent; the coarse aggregate was a graded gravel from the No. 4 to ¾-in. sizes.

---

[1] Associate Professor of Theoretical and Applied Mechanics, and Instructor in General Engineering, respectively, Iowa State College, Ames, Iowa.

Proportions:

The same mix was used in all batches. This mix was determined after a preliminary study of the relationship between strength, curing, water pressure, specimen thickness and leakage; it was desirable in this study to produce a concrete representative of that used in common practice, which, under the conditions of test would show rates of leakage enabling comparison of results between batches with and without waterproofing agents. The mix used was 1:3:3 by weight, 7½ gal. of net water per bag of cement. The consistency was maintained at a slump of approximately 6½ in.; additional water was found necessary to maintain this slump when admixtures A and B were used.

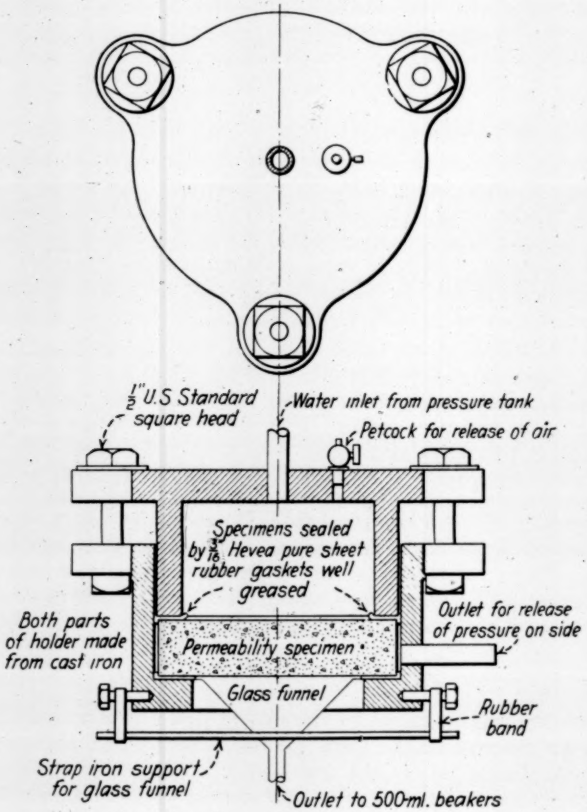

½" U.S Standard square head
Water inlet from pressure tank
Petcock for release of air
Specimens sealed by 3/16 Hevea pure sheet rubber gaskets well greased
Both parts of holder made from cast iron
Permeability specimen
Outlet for release of pressure on side
Glass funnel
Rubber band
Strap iron support for glass funnel
Outlet to 500-ml. beakers

FIG. 1.—Specimen Holder.

Mixing and Placing:

All aggregates were taken from saturated stock piles and water adjusted for the free moisture. The proportioning was by the weighing of all ingredients. Following the mixing a density measure and analysis of the fresh concrete was made.

The specimens were fabricated by two methods. In the first run all were rodded; in an effort to increase uniformity, this was changed in all later runs to placing of the specimen holders on a flow table, covering them with a mass of concrete and consolidating by dropping the table 20 times.

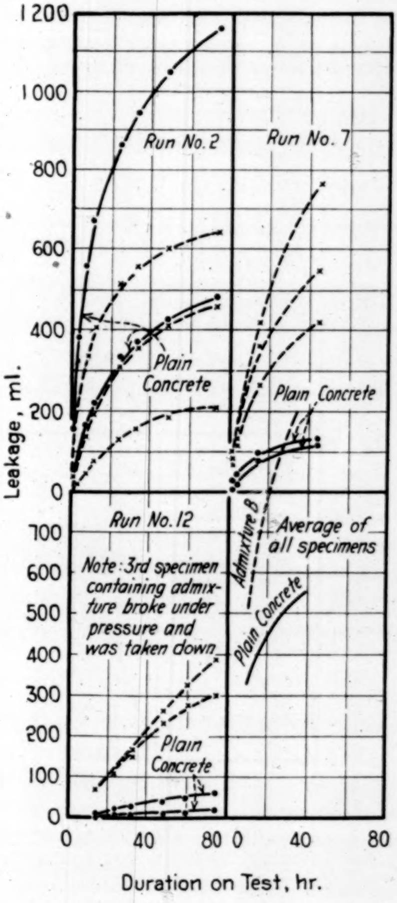


FIG. 2.—Admixture B—Series No. 1.

Curing:

(*a*) In series 1 the specimens were all cured 7 days in moist sand followed by 21 days in the air of the laboratory.

(*b*) In series 2 each of the five specimens was cured differently; one, no immersion, one 3 days, one 7 days, one 14 days and one 21 days immersed in water followed by the remainder of the 28 days in the air of the laboratory.

Four compression specimens were made from each batch; two of these were moist cured for 7 days and tested wet at 28 days, the remaining two were moist cured for 28 days and tested.

NUMBER OF SPECIMENS TESTED

Comparable results in permeability studies are obtained only after sufficient specimens of one type have been tested to indicate that there is a consistent quality in that type. In series 1 of this investigation, five specimens were fabricated and tested, two of them consisting of plain concrete and three of waterproofed concrete made, cured and tested under the same conditions. This was repeated three times for series 1; this was followed by series 2 where the curing was varied, and five specimens made of each type, only one round being made. The total permeability specimens tested was 115, 14 for each type of waterproofing. The number of compression specimens was 155.

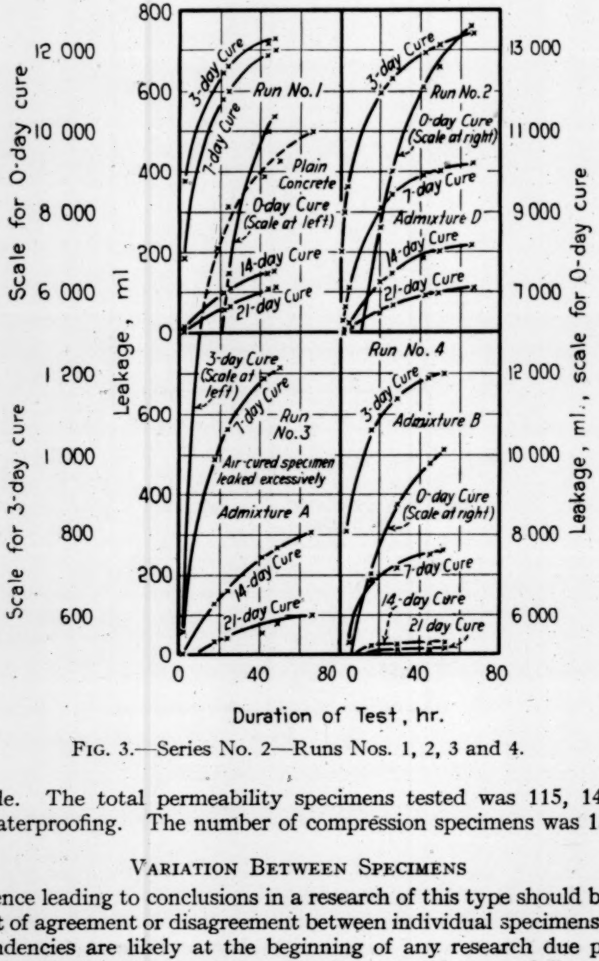


FIG. 3.—Series No. 2—Runs Nos. 1, 2, 3 and 4.

VARIATION BETWEEN SPECIMENS

Evidence leading to conclusions in a research of this type should be weighed in the light of agreement or disagreement between individual specimens. Certain erratic tendencies are likely at the beginning of any research due principally to lack of familiarity with apparatus or technique; this type of disagreement is not serious and can always be detected by noting that such variations become less evident in subsequent tests. Disagreements which are consistently of such amounts or nature as to be noticeable throughout should be considered as typical of the material tested. Both types of variations are found in this research.

The results from the first round of specimens showed evident variations between specimens; these disappeared with improvement in fabrication and curing methods. Other consistent variations occurred throughout the tests. To illustrate this point briefly the total leakage curves for individual specimens of one type of concrete are shown in Fig. 2. Run No. 2 was the first group made; these are quite erratic, this being true of the entire first round; runs Nos. 7 and 12 are the second and third groups of this type and it is seen that this erratic nature has disappeared. The variation in this case may be partly attributed to the fact that curing in the sand was not subject to sufficiently accurate control.

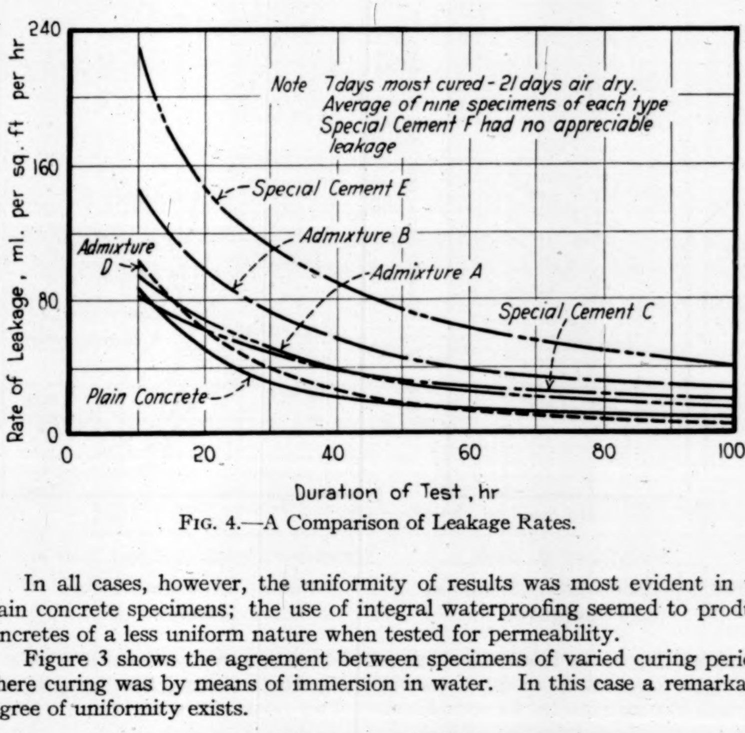


FIG. 4.—A Comparison of Leakage Rates.

In all cases, however, the uniformity of results was most evident in the plain concrete specimens; the use of integral waterproofing seemed to produce concretes of a less uniform nature when tested for permeability.

Figure 3 shows the agreement between specimens of varied curing periods where curing was by means of immersion in water. In this case a remarkable degree of uniformity exists.

COMPRESSIVE STRENGTH AND WATER-TIGHTNESS

The effect of the waterproofing materials upon the compressive strength is well indicated in Fig. 5. Only the high-early-strength cement produced an increase in strength. The hydrated lime may be considered as having no effect although there is indication of increase in the 7-day strength with loss at 28 days.

Figure 4 shows the effect of these same ingredients upon the permeability. All curves are the average of nine specimens. After 60 hr. of leakage only the concretes containing the hydrated lime or the special cement F show any improvement over plain concrete. Before the fortieth hour there appears to be an unstable condition, special cement C actually having an initial leakage rate lower than that of plain concrete. This unstable period for different types of concrete is interesting in view of the fact that with each type the individual specimens exhibited the same characteristic with respect to each other, so that the final curve is not due to averaging but is a definite characteristic.

The concrete containing special cement F was water-tight under the conditions shown in Fig. 4.

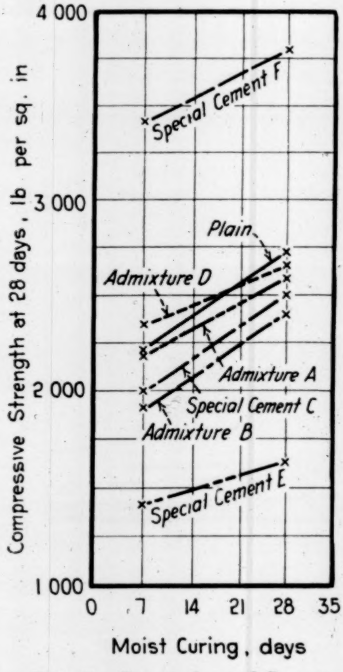


FIG. 5.—Comparison of Compressive Strengths.

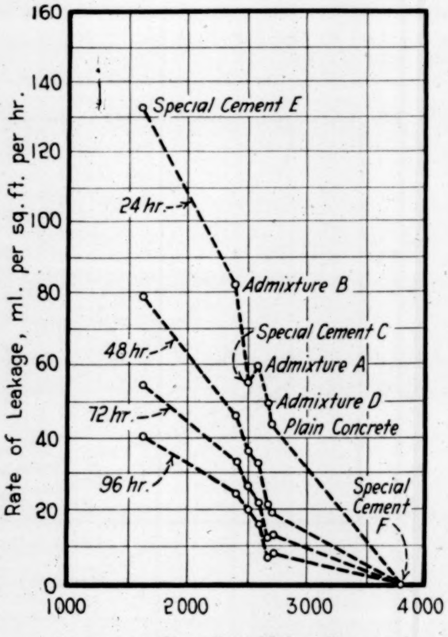


FIG. 6.—Strength-Leakage Curves.

From Fig. 6, the rates of leakage plotted against the compressive strength, it is apparent that an integral waterproofing which reduces the strength of a concrete also reduces its water-tightness. This relationship was quite marked from the twenty-fourth hour of test on.

The effect of the length of moist curing period upon permeability as given in Fig. 7 indicates a continued improvement in water-tightness as the period of curing is lengthened. The major portion of this improvement was seen to occur during the first 7 days. The specimens were cured by immersion in water and an improvement as compared with sand curing (see forty-eighth hour in Figs. 4 and 6) is shown in concretes containing admixture B and special cement E. This improvement, however, was not enough to provide a substantial decrease in leakage as compared to increased curing of the plain concrete, and it seems doubtful that such a condition of curing could be duplicated in practice.

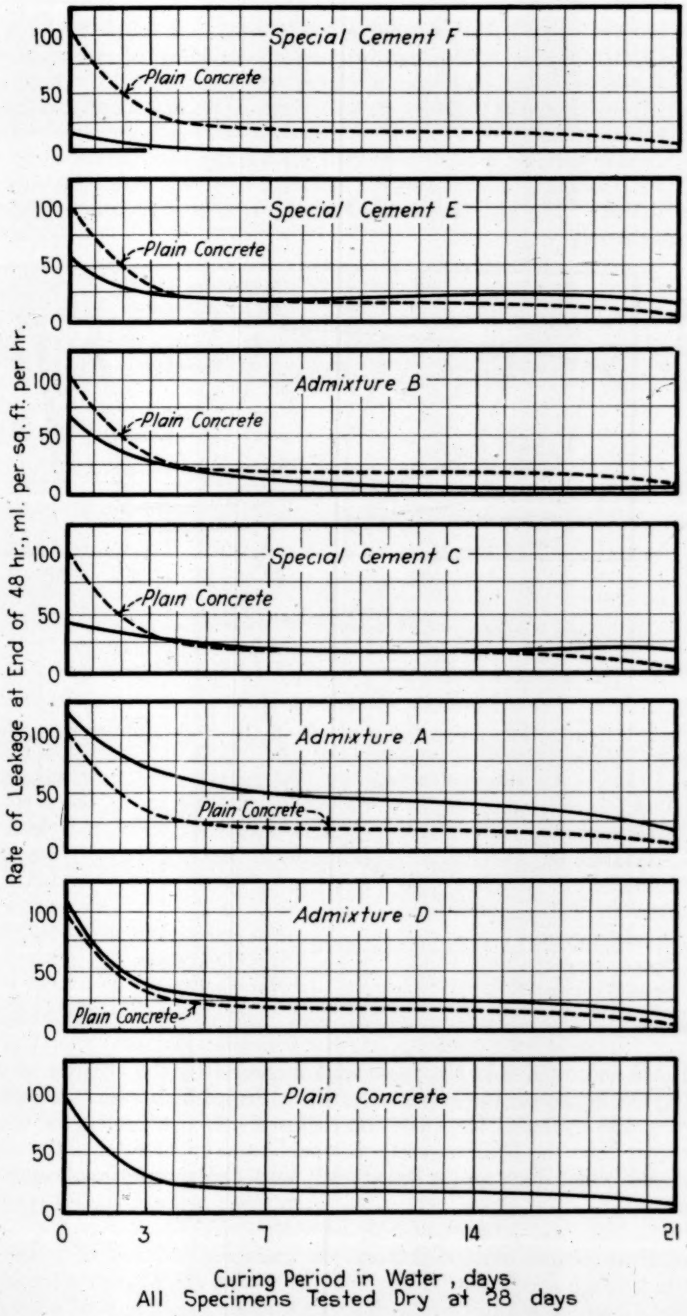


FIG. 7.—Comparison of Rate-Curing Curves of Series No. 2.

ABSORPTION DATA

Absorption data were obtained by carefully weighing all specimens whenever removed from one condition of curing and when tested. These values when plotted indicated that obvious relations existed between curing and absorption, but variations in the amounts absorbed during permeability testing were extremely variable and of such small percentages that the accuracy maintained in the weighing devices was not sufficient to detect assignable causes for the deviations. The general character of the results is shown in Fig. 8 for one concrete only.

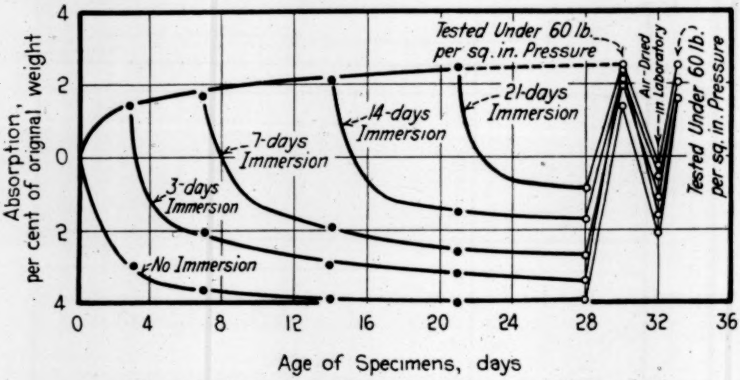


FIG. 8.—Absorption of Hydrated Lime Specimens.

VOID DETERMINATIONS

Void determinations upon the concrete in the fresh state were made with each mix:

TYPE	AIR VOIDS, PER CENT	WEIGHT, LB. PER CU. FT.
Plain concrete	0.3	145.5
Admixture D	0.1	146.1
Admixture A	1.4	143.7
Admixture B	2.2	143.4
Special cement F	Not completed[a]	144.5
Special cement C	Not completed[a]	141.3
Special cement E	Not completed[a]	143.8

---

[a] Specific gravity of cements not known.

These data indicated that the voids were increased by the addition of waterproofing mediums with the exception of the hydrated lime. Since all concretes excepting the hydrated lime and the high-early-strength concretes were less water-tight than the plain concrete, it would seem apparent that the addition of materials which decrease the density will produce less waterproof concretes.

FORM OF THE LEAKAGE CURVES

In these studies water-tightness was measured by flow of water under pressure through specimens. Since the rate of flow under such conditions has repeatedly been shown to be of a characteristically reducing rate, observations which might clarify this phenomenon were carefully taken. Visual inspection repeatedly demonstrated the following occurrence: a specimen permitting the passage of water at a definite rate at 24 hr. displayed a leakage rate reducing to zero at 48 hr.; then after 72 hr. the lower surface of the specimen if exposed to air became dry; this same specimen after being tested for a longer period, removed and broken open for inspection indicated that the depth of penetration of the water under pressure was actually receding. This observation should have definite consideration when testing for water-tightness by the bomb type of test.

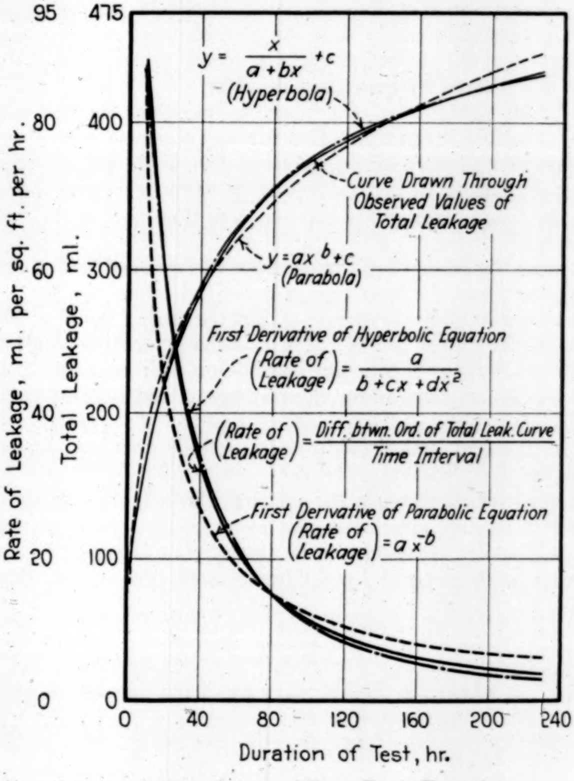


FIG. 9.—A Comparison of Type Form Equations.

Since discussion has previously appeared relative to the mathematical form of the leakage curves, it was thought worth while to investigate this matter briefly.

Only two type form equations were found which would closely approximate the total leakage curves; these were:

1. Parabolic types of the form $y = ax^b + c$, and
2. Hyperbolic types of the form $y = \frac{x}{a + bx} + c$.

A comparison of these two forms for actual leakage curves is shown in Fig. 9.

Rates of leakage are, of course, given by the first derivative of the equation representing the total leakage. The two type forms, therefore, were differentiated and resulting values compared with the rates of leakage obtained by the usual method of dividing the difference between two ordinates by the time interval between. A comparison of these values is also shown on Fig. 9.

It is evident that if the rates of leakage are to be obtained from differentiated type forms, or if leakage curves are to be interpolated or extended the hyperbolic type should be used.

CONCLUSIONS

1. The chosen integral waterproofing materials adversely affected the strength and water-tightness of the concrete cured either in moist sand or water, with the exception of the concrete containing special cement F, and the bentonite admixture B when cured by immersion in water.

2. The water-tightness of the concrete increased as the curing period lengthened. The first seven days of curing was the most critical period in the obtaining of water-tightness, since a major portion of the improvement occurred in that time; variations in method of curing within this period had a greater effect upon the water-tightness of the concrete than the use of admixtures or special cement.

3. The more the strength of the concrete was reduced by the waterproofing agents, the greater was the reduction in water-tightness (Fig. 6).

4. Due to the *unstable* conditions of leakage during the first 40 hr. of test, a comparison of the rate of leakage as a final characteristic of individual specimens or of different types of concrete was best made from results obtained from test periods of 40 hr., extending this further if consistent results were not obtained.

5. No convenient relationship was found between absorption and permeability.

6. Materials which increase the voids in the concrete by the addition of water or by bulking the ingredients also decreases the water-tightness.

7. If total leakage curves are to be extended or interpolated, or if rates of leakage are to be determined from differentiated type forms, the hyperbolic equation:

$$y = \frac{x}{a + bx} + c$$

should be used, in which y is total leakage and x the duration of test.

REPORT OF COMMITTEE C-10
ON
HOLLOW MASONRY BUILDING UNITS

Committee C-10 on Hollow Masonry Building Units at a meeting held in Atlantic City on June 26, 1934, during the annual meeting of the Society gave consideration to various suggestions that had been received for improvements of the specifications and methods of tests for structural clay tile and for concrete building units under its jurisdiction. At this meeting the recommendations recorded below were approved for reference to letter ballot of the committee to be referred subsequent to the annual meeting to the Society for acceptance through Committee E-10 on Standards:[1]

I. *Proposed Tentative Standard.*—The methods of test for structural clay tile formerly published in the several standard specifications, which standards were now to be withdrawn, were recommended for publication separately as tentative under the title, "Tentative Methods of Sampling and Testing Structural Clay Tile."[2]

II. *Proposed Revisions of Tentative Standards.*—Revisions were recommended in the following four specifications and one definition which are to be continued as tentative in their revised form:

Tentative Specifications and Tests for Load-Bearing Concrete Masonry Units (C 90 – 33 T),[3] revised to require drying of the units before acceptance. This change is believed to be essential as a safeguard against excessive shrinkage in service.

Tentative Specifications for Structural Clay Load-Bearing Wall Tile (C 34 – 33 T),[3] revised to include a new paragraph on color and an increase in the compressive strength requirements for side construction tile of class 16–25. It was believed that the present strength requirements were not sufficient to insure adequate wall strength in all cases.

Tentative Specifications for Structural Clay Non-Load-Bearing Tile (C 56 – 33 T),[3] revised to include a new paragraph on color.

Tentative Specifications for Structural Clay Floor Tile (C 57 – 33 T),[3] revised to include a new paragraph on color.

Tentative Definitions of Terms Relating to Structural Clay Tile (C 43 – 33 T),[3] revised definition of the term "structural clay tile."

---

[1] For the action taken on these recommendations by Committee E-10 on Standards see the Editorial Note, p. 394.—Ed.

[2] See p. 776.—Ed.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 667 to 683 (1933); also 1933 Book of A.S.T.M. Tentative Standards, pp. 346 to 362.

III. *Withdrawal of Standards.*—The following four standards have been superseded by the tentative specifications and definitions mentioned above and it is accordingly proposed that they be discontinued:

Standard Specifications and Tests for Structural Clay Load-Bearing Wall Tile (C 34 – 31)[1]

Standard Specifications and Tests for Structural Clay Fireproofing, Partition and Furring Tile (C 56 – 31)[1]

Standard Specifications and Tests for Structural Clay Floor Tile (C 57 – 31)[1]

Standard Definitions of Terms Relating to Structural Clay Tile (C 43 – 31)[1]

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

Respectfully submitted on behalf of the committee,

D. E. PARSONS,
Chairman.

F. E. EMERY,
Secretary.

EDITORIAL NOTE

Recommendations to Committee E-10 on Standards.—Subsequent to the annual meeting Committee C-10 on Hollow Masonry Building Units presented to the Society through Committee E-10 on Standards the following recommendations which were accepted by Committee E-10 on August 22, 1934:

Proposed Tentative Methods of Sampling and Testing Structural Clay Tile were accepted for publication as tentative and appear on page 776.

A revision of the Tentative Specifications and Tests for Load-Bearing Concrete Masonry Units was accepted. The specifications in their revised form appear on page 772.

Revisions of the Tentative Specifications for Structural Clay Load-Bearing Wall Tile, for Structural Clay Non-Load-Bearing Tile, and for Structural Clay Floor Tile, were accepted and the withdrawal of the standard specifications for these materials was approved since the tentative specifications supersede the former standards. The tentative specifications in their revised form appear on pages 768, 765 and 761.

The withdrawal of the Standard Definitions of Terms Relating to Structural Clay Tile was accepted since these have been superseded by the tentative definitions issued in 1933. A proposed revision of the definition for "structural clay tile," appearing in the Tentative Definitions of Terms Relating to Structural Clay Tile, was referred back to Committee C-10 for further consideration.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, pp. 141, 137, 132 and 147, respectively.

REPORT OF COMMITTEE C-11
ON
GYPSUM

Committee C-11 on Gypsum held but one meeting this year; on March 7, 1934, in Washington, D. C., in conjunction with the Spring Group Meetings of A.S.T.M. Committees. The four subcommittees of Committee C-11 also held meetings on March 7, which were very well attended. Considerable work was outlined for each of the subcommittees and it is expected that they will meet again this fall, at the time of the meeting of Committee C-11, to review the work accomplished.

One member of the committee has proposed the lowering of the present minimum weight requirements in the Tentative Specifications for Gypsum Wall Board (C 36 – 31 T), for Gypsum Lath (C 37 – 31 T) and for Gypsum Sheathing Board (C 79 – 31 T). This suggestion was thoroughly discussed by the committee at the March meeting and the results of the tests conducted by one member were considered. The committee, however, felt that the results of a more thorough series of tests were necessary before it could justify a recommendation that the present minimum weight requirement in these specifications be lowered.

Recommendations Affecting Standards

I. *Adoption of Tentative Standards as Standard.*—The tentative specifications for gypsum board under the jurisdiction of the committee have been tentative for three years and, with the exception of the recommendation for a lower minimum weight requirement, mentioned above, no changes have been suggested. The committee therefore recommends the submission of the following tentative specifications to letter ballot of the Society for adoption as standard:

Tentative Specifications for Gypsum Wall Board (C 36 – 31 T)[1]
Tentative Specifications for Gypsum Lath (C 37 – 31 T)[1]
Tentative Specifications for Gypsum Sheathing Board (C 79 – 31 T)[1]

II. Tentative Standard Continued as Tentative.—The Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 – 31 T) have been tentative for three years without revision. No action has been taken by the committee with respect to the definitions, owing to the fact that with the exception of the March, 1934, meeting the committee has not met since 1932. Consideration will be given to the definitions at the fall meeting of the committee.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 740 to 748 (1931); also 1933 Book of A.S.T.M. Tentative Standards, pp. 302 to 310.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 27 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Tentative Specifications for Gypsum Wall Board (C 36 - 31 T)	23	0	3
Tentative Specifications for Gypsum Lath (C 37 - 31 T)	23	0	3
Tentative Specifications for Gypsum Sheathing Board (C 79 - 31 T)	23	0	3

This report has been submitted to letter ballot of the committee, which consists of 27 members; 26 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

J. W. GINDER,
Chairman.

H. J. SCHWEIM,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Gypsum Wall Board, for Gypsum Lath and for Gypsum Sheathing Board were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 91 to 99, inclusive.

REPORT OF COMMITTEE C-13
ON
CONCRETE PIPE

Committee C-13 on Concrete Pipe was organized at a meeting held in Philadelphia on November 14, 1932. The organization of this committee came about as a result of a decision by the Executive Committee of the Society to divide the former Committee C-4 on Clay and Concrete Pipe into two committees dealing separately with these two kinds of pipe. Committee C-13 has been assigned jurisdiction over the specifications for concrete pipe developed by the original committee. The following two subcommittees have been appointed to sponsor the activities of the committee: Subcommittee I on Concrete Sewer Pipe (Unreinforced and Reinforced) and Subcommittee II on Reinforced Concrete Culvert Pipe.

Since its organization, the committee has held two meetings: at Chicago, Ill., in June, 1933, and at Washington, D. C., in March, 1934. The subcommittees have also been active and have held several meetings. The committee has given consideration to revisions of the several specifications for which it is responsible and is presenting in this report revisions in two of these specifications and recommending the continuation as tentative of a third specification.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Revision of Standard:

Standard Specifications for Cement-Concrete Sewer Pipe (*C 14-24*).[1]—The committee has through its Subcommittee I on Concrete Sewer Pipe (Unreinforced and Reinforced) (S. A. Greeley, chairman) made a thorough study of these standard specifications for concrete pipe and has prepared a number of revisions which are now proposed for acceptance. The title will be changed to indicate that the specifications cover "non-reinforced" concrete sewer pipe, and a number of improvements have been made in form and arrangement of the text. Changes in substance include a reduction in the number of pipe furnished for testing purposes, and the elimination of all reference to the knife or two-edge bearing method for the crushing strength test. In the three-edge bearing method provision is being made to permit the use of a fillet of plaster of Paris on the bearings to compensate for inequalities of the pipe barrel so as to provide a uniform bearing in the crushing strength test. All reference to pipe larger than 24 in. in internal diameter has been deleted from the specifications; these sizes will now be covered in the Tentative Specifications for Reinforced-Concrete Pipe (C 75 - 30 T). These revisions have been incorporated in the proposed Tentative Specifications for Non-Reinforced Concrete Sewer Pipe, appended hereto,[1] which the committee recommends for publication as a tentative revision of the present Standard Specifications C 14 - 24.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 207.

II. Revision of Tentative Standard:

Tentative Specifications for Reinforced-Concrete Pipe (C 75 - 30 T).[2]—Through Subcommittee I the committee has also prepared a number of important changes in these specifications for reinforced-concrete pipe. The title is to be changed to indicate that the specifications cover concrete sewer pipe and the scope clause will be amplified to indicate that the specifications are intended for reinforced-concrete pipe for the conveyance of sewage, industrial waste and storm waters. The strength test requirements for standard reinforced-concrete pipe from 24 to 72 in. in internal diameter have been considerably increased. The minimum design requirements for the standard class of pipe have been increased from 2750 to 3000 lb. per sq. in., from 4000 to 4500 and from 4500 to 5000 lb. per sq. in. The test requirements for extra-strength reinforced-concrete pipe in diameters from 24 to 72 in. have been increased in the smaller sizes and slightly reduced in the larger diameters. Certain minor changes have also been made in the required steel areas for both classes of pipe. The paragraph relating to the submission of alternate designs by the manufacturer has been eliminated. The revised specifications require the manufacturer to furnish for test up to 0.5 per cent of the pipe in each size from 24 to 36 in. but in no case less than two specimens. These revisions have been incorporated in the proposed revised tentative specifications appended hereto,[3] which the committee recommends be accepted for publication.

III. Tentative Specifications Continued as Tentative:

Tentative Specifications for Reinforced-Concrete Culvert Pipe (C 76 - 30 T).[2]—These specifications have been tentative for more than three years. Consideration is being given, however, to revisions of these specifications by Subcommittee II on Reinforced Concrete Culvert Pipe (E. F. Kelley, chairman) and the committee accordingly recommends that they be continued as tentative.

---

[1] See p. 809.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 1040 and 1051 (1930); also 1933 Book of A.S.T.M. Tentative Standards, pp. 387 and 398.

[3] See p. 822.—ED.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 21 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF STANDARD			
Specifications for Cement-Concrete Sewer Pipe (C 14 - 24)	13	0	0
II. REVISION OF TENTATIVE STANDARD			
Specifications for Reinforced Concrete Pipe (C 75 - 30 T)	12	1	0

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee, which consists of 21 members; 13 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

A. E. PHILLIPS,
Chairman.

M. W. LOVING,
Secretary.

EDITORIAL NOTE

The proposed revision of the Standard Specifications for Cement-Concrete Sewer Pipe in the form of new tentative specifications entitled "Tentative Specifications for Non-Reinforced Concrete Sewer Pipe" was accepted for publication as tentative and appears on page 809.

The revisions of the Tentative Specifications for Reinforced Concrete Pipe, as modified on the floor of the annual meeting, see Summary of Proceedings, page 26, were accepted. The specifications in their revised form appear on page 822.

REPORT OF COMMITTEE D-1
ON
PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS

Committee D-1 on Preservative Coatings for Structural Materials held its meeting on March 28, 1934, in St. Petersburg, Fla., in conjunction with the meeting of the Paint and Varnish Division of the American Chemical Society.

A number of subcommittees have been very active during the past year in their several lines of work, developing new specifications and test methods, with the result that quite complete reports were presented by them to Committee D-1.

Since the last annual meeting, 13 new members have been elected, 12 resignations have been accepted and 1 death reported, leaving a total membership of 173.

The work of the active subcommittees during the past year has resulted in the committee making the following recommendations to be acted upon at the annual meeting:

I. Six new tentative specifications and one tentative method of test are being submitted;

II. Revision is proposed as tentative in one standard method, and further revision is proposed in two tentative revisions of standard methods; also an editorial revision of one standard;

III. Revision is proposed in one tentative specification and two tentative methods of test;

IV. Three tentative specifications are recommended for adoption as standard;

V. One tentative revision of an existing standard specification is recommended for adoption as standard.

RECOMMENDATIONS AFFECTING STANDARDS

In this report, recommendations affecting standards and tentative standards are noted in brief form below, together with the results of the letter ballot. These recommendations are explained in the reports of the subcommittees directly responsible for them.

I. Proposed Tentative Standards.—The committee submits for publication as tentative, the following six new specifications and one method of test, as appended hereto:

Tentative Specifications for Titanium Barium Pigment,[1] as proposed by Subcommittee XV;

Tentative Specifications for Titanium Calcium Pigment,[2] as proposed by Subcommittee XV;

Tentative Specifications for Titanium Dioxide,[3] as proposed by Subcommittee XV;

Tentative Specifications for High Zinc Sulfide Lithopone,[4] as proposed by Subcommittee XV;

Tentative Specifications for Zinc Sulfide,[5] as proposed by Subcommittee XV;

Tentative Specifications for Amyl Acetate (from Fusel Oil) (85 to 88 per cent Grade),[6] as proposed by Subcommittee XXV;

Tentative Methods of Test for Mass Color and Tinting Strength of Dry Color Pigments or Pastes,[7] as proposed by Subcommittee VIII.

II. Proposed Revisions of Existing Standards.—The committee recommends that the revisions in the following standard methods, as proposed by Subcommittee VIII in its report appended hereto, be accepted for publication as tentative:

Standard Methods of Routine Analysis of Dry Red Lead (D 49 – 33);[8]

Standard Methods of Routine Analysis of White Linseed Oil Paints (D 215 – 29),[8] as further revised;

Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 – 27),[8] as further revised.

The committee further recommends that the revision in the Standard Methods of Sampling and Testing Shellac (D 29 – 33),[8] as proposed by Subcommittee XIII in its report appended hereto, be accepted as an editorial change.

III. Revisions of Tentative Standards.—The committee recommends that the following tentative specification and tentative methods of test be revised as given in detail in the reports of the respective subcommittees and continued as tentative:

Tentative Specifications for Petroleum Spirits (Mineral Spirits) (D 235 – 26 T),[9] as proposed by Subcommittee XI;

Tentative Method of Test for Tinting Strength of White Pigments (D 332 – 31 T),[10] as proposed by Subcommittee VIII;

Tentative Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 – 33 T),[11] as proposed by Subcommittee XXV.

---

[1] See p. 856.—ED.

[2] See p. 858.—ED.

[3] See p. 860.—ED. [4] See p. 862.—ED. [5] See p. 864.—ED.

[6] See p. 878.—ED. [7] See p. 871.—ED.

[8] 1933 Book of A.S.T.M. Standards, Part II, pp. 562, 583, 617, 678.

[9] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 793 (1926); also 1933 Book of A.S.T.M. Tentative Standards, p. 491.

[10] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 797 (1931); also 1933 Book of A.S.T.M. Tentative Standards, p. 525.

[11] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 741 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 518.

IV. Adoption of Tentative Standards as Standard.—The committee recommends that the following tentative specifications be adopted as standard:

Tentative Specifications for Spirits of Turpentine (D 13 - 33 T),[1] as proposed by Subcommittee XII.

Tentative Specifications for Shellac Varnish (D 359 - 33 T),[1] revised as proposed by Subcommittee XIII.

Tentative Specifications for Centrifuged Shellac Varnish (D 360 - 33 T),[1] revised as proposed by Subcommittee XIII.

V. Adoption as Standard of Tentative Revision of Existing Standard.—The committee recommends that the tentative revision proposed last year[2] in the following existing standard be adopted as standard:

Revision of Standard Specifications for Basic Carbonate White Lead (D 81 - 31), as proposed by Subcommittee XV.

The above recommendations have been submitted to letter ballot of the committee, which consists of 173 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARDS			
Specifications for Titanium Barium Pigment	41	1	15
Specifications for Titanium Calcium Pigment	41	0	16
Specifications for Titanium Dioxide	43	0	14
Specifications for High Zinc Sulfide Lithopone	33	1	23
Specifications for Zinc Sulfide	32	2	23
Specifications for Amyl Acetate (from Fusel Oil)	27	0	30
Methods of Test for Mass Color and Tinting Strength of Dry Color Pigments or Pastes	41	0	16
II. PROPOSED REVISIONS OF EXISTING STANDARDS			
Methods of Routine Analysis of Dry Red Lead (D 49 - 33)	41	0	16
Methods of Routine Analysis of White Linseed Oil Paints (D 215 - 29)	42	0	15
Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 - 27)	42	0	15
Methods of Sampling and Testing Shellac (D 29 - 33), editorial revision	30	0	27
III. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Specifications for Petroleum Spirits (Mineral Spirits) (D 235 - 26 T)	43	1	13
Method of Test for Tinting Strength of White Pigments (D 332 - 31 T)	43	3	11
Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 - 33 T)	32	0	25
IV. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications for Spirits of Turpentine (D 13 - 33 T)	49	5	21
Specifications for Shellac Varnish (D 359 - 33 T), as revised	29	0	28
Specifications for Centrifuged Shellac Varnish (D 360 - 33 T), as revised	28	0	29
V. ADOPTION AS STANDARD OF TENTATIVE REVISION OF EXISTING STANDARD			
Standard Specifications for Basic Carbonate White Lead (D 81 - 31)	42	0	15

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 725, 727, 729 (1933); also 1933 Book of A.S.T.M. Tentative Standards, pp. 498, 500, 502.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 1036 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 1074.

ACTIVITIES OF SUBCOMMITTEES

Appended hereto are reports of the following subcommittees:

Subcommittee VIII on Methods of Analysis of Paint Materials;

Subcommittee XIII on Shellac;

Subcommittee XV on Specifications for Pigments Dry and In Oil When Marketed in That Form; and

Subcommittee XXV on Cellulose Ester Coatings.

In addition to the subcommittee reports appended, the activities of other subcommittees are reported as follows:

Subcommittee VII on Accelerated Tests for Protective Coatings (H. A. Nelson, chairman).—This subcommittee reports that Group 3 on Varnishes and Group 4 on Lacquers have active cooperative test programs under way to determine available test cycles, specifically applicable to the types of finishes to be studied. Group 5 on Test Panel Wood Specifications has developed data for a tentative specification for northern white pine for paint exposure purposes. The object is to represent a wood approximately midway between edge grain western red cedar as specified in the Tentative Specifications for Wood to be Used as Panels in Accelerated Weather Tests of Paints and Varnishes (D 358 - 33 T),[1] and wood such as yellow pine. This group plans to write specifications for Douglas fir, cypress and southern yellow pine for use in the construction of exposure panels. The subcommittee further reports that it is prepared to accept the responsibility for development of specific accelerated tests within the ability of its individual members to give time to such activities. It is believed by the subcommittee that as yet there is no general accelerated test available that is equally applicable to all types of finishing materials. As a laboratory tool for proving some specific points, so-called "accelerated weathering tests" appear to have been of value to individual laboratories when conducted by operators having experience in testing of organic finishes.

Subcommittee IX on Varnish (W. T. Pearce, chairman).—This subcommittee reports progress for three of its groups: Group 1 on Development of a Standard Method for Determining Acid Values; Group 2 on Development of a Standard Test for Skinning; and Group 4 on Development of a Standard Adhesion Test. Group 3 on Development of a Standard Test for Alkali Resistance has completed its work and an abstract of the report submitted follows:

Tests were made with three varnishes representing different degrees of alkali resistance, as follows:

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 745 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 522.

Varnish A conformed to Navy Department Specification V-10 for Aircraft Spar Varnish. A 36-gal. varnish made with synthetic resin of the 100 per cent phenolic type.

Varnish B was a 50-gal. spar varnish of the following composition:

Resin { 50 per cent phenolic resin (100 per cent type)
50 per cent rosin ester

Oil { 87.5 per cent tung oil
12.5 per cent linseed oil

Varnish C conformed to the Federal Specification for Water-Resisting Spar Varnish (TT-V-121).

Four series of tests were run as follows:

Series I. Poured on tin plate panels. Exposed by immersion.

Series II. Poured on glass panels. Exposed by immersion.

Series III. Test tubes dipped and allowed to dry mouth downward. Exposed by immersion.

Series IV. Brushed on large tin panels. Exposed by placing a small puddle of the test solution on the panel and covering with a watch glass.

Sodium hydroxide solutions were used in concentrations of 1, 2, 3 and 5 per cent, respectively.

Observations were made hourly during the first 8 hr., also after 16 hr., 24 hr. and 48 hr. The points noted were: (1) dulling, (2) clouding or whitening, (3) blistering, (4) removal from surface, and (5) loss of toughness.

The conclusions and recommendations resulting from this work are:

1. Alkali resistance tests are so severe that their use should be limited to varnishes of the most alkali-resistant type.
2. It is suggested that test tubes be used as the testing surface.
3. A drying time of 48 hr. under normal room conditions is recommended.
4. A 3 per cent solution of sodium hydroxide is suggested as a suitable concentration and 70 F. ± 5 F. is proposed as the proper temperature for conducting the test.
5. For making examination, the tubes should be rinsed under a gentle stream of water, then allowed to air dry for about 30 minutes.
6. A reasonable requirement is that after immersion for 16 hr. the varnish shall show no whitening, blistering or removal.

Subcommittee XI on Paint Thinners Other Than Turpentine (Lyman Quincy, chairman).—This subcommittee recommends that the present Tentative Specifications for Petroleum Spirits (Mineral Spirits) (D 235 - 26 T)[1] be continued as tentative with the following revisions:

Section 2 (c).—Change the specified requirement for flash point to read as follows by the addition of the italicized figures and the omission of those in brackets:

(*c*) Flash Point.—The flash point shall not be lower than [86 F. (30 C.)] *100 F.* (*38 C.*) when tested in the Tag closed tester.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 793 (1926); also 1933 Book of A.S.T.M. Tentative Standards, p. 491.

Section 2 (e).—Change the specified requirements for distillation from their present form: namely,

> (*e*) *Distillation.*—The distillate below 266 F. (130 C.) shall not exceed 5 per cent.
>
> The distillate below 446 F. (230 C.) shall not be less than 97 per cent.

to read as follows:

> (*e*) *Distillation Range.*—Not less than 50 per cent shall be recovered in the receiver when the thermometer reads 350 F. (177 C.). The dry or end point shall not be higher than 410 F. (210 C.).

A questionnaire sent out to the majority of paint and varnish manufacturers by the subcommittee regarding distillation range and flash point actually required for a product of the class of petroleum solvents in question, indicated that the changes now being recommended met with their approval. The subcommittee reports its intention to study possibilities of incorporating in these specifications a method for determining solvent power of mineral thinners. The proposal of Subcommittee XII on Flash Point, of Committee D-2 on Petroleum Products and Lubricants, to incorporate in the Standard Method of Test for Flash Point of Volatile Flammable Liquids (D 56 – 21), in the form of a footnote to the present method, the changes[1] proposed in the 1933 report of Committee D-1 has been considered. This method of handling these modifications is acceptable to this subcommittee provided laboratory check tests be conducted and studied.

Subcommittee XII on Turpentine (F. P. Veitch, chairman).—This subcommittee recommends for adoption as standard the Tentative Specifications for Spirits of Turpentine (D 13 – 33 T).

Subcommittee XXIII on Anti-Fouling Paints (A. M. Muckenfuss, chairman).—This subcommittee, in a report of progress, calls attention to the results of underwater exposure tests of marine paints containing a tung oil vehicle. Information regarding these tests was presented in a paper before the Paint and Varnish Division of the American Chemical Society at their Florida meeting, March 27, 1934.

Subcommittee XXVI on Underground Pipe Protection (F. N. Speller, chairman).—This subcommittee reports that it has been actively engaged in work on the matter of priming coats and that progress has been made toward development of a tentative specification restricted, for the present, to bituminous type primers. The subcommittee is desirous of seeing developed in the near future, a standard method of measuring adhesion of paint coatings to metal, and standard methods for testing paint coatings under water.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 328 (1933).

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee, which consists of 173 members; 57 members have returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

ALLEN ROGERS,
Chairman.

M. REA PAUL,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Titanium Barium Pigment, for Titanium Calcium Pigment, for Titanium Dioxide, for High Zinc Sulfide Lithopone, for Zinc Sulfide, for Amyl Acetate (from Fusel Oil) (85 to 88 per cent Grade), and Methods of Test for Mass Color and Tinting Strength of Dry Color Pigments or Pastes were accepted for publication as tentative and appear on pages 856 to 875, inclusive.

The proposed revisions of the Standard Methods of Routine Analysis of Dry Red Lead, of White Linseed Oil Paints, and of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green were accepted for publication as tentative and appear on pages 1265, 1266 and 1269, respectively. The proposed editorial revision of the Standard Methods of Sampling and Testing Shellac was accepted.

The revisions of the Tentative Specifications for Petroleum Spirits (Mineral Spirits), Method of Test for Tinting Strength of White Pigments and Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels were accepted. The specifications and methods in their revised form appear on pages 876, 866 and 879, respectively.

The Tentative Specifications for Shellac Varnish and for Centrifuged Shellac Varnish, as revised, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 113 and 115, respectively. The Tentative Specifications for Spirits of Turpentine, recommended on the floor of the annual meeting for adoption as standard, see Summary of Proceedings, page 3, were subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, page 111.

The tentative revision of the Standard Specifications for Basic Carbonate White Lead was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934. The specifications in their revised form appear in the 1934 Supplement to Book of A.S.T.M. Standards, page 109.

REPORT OF SUBCOMMITTEE VIII ON METHODS OF ANALYSIS OF PAINT MATERIALS

Subcommittee VIII has completed the preparation of tests for mass color and tinting strength of colored pigments, following generally the specifications for the testing of dry color shipments of the Federation of Paint and Varnish Production Clubs. The subcommittee accordingly submits the proposed Tentative Methods of Test for Mass Color and Tinting Strength of Dry Color Pigments, appended hereto,[1] and recommends them for publication as tentative.

The subcommittee has received several suggestions regarding desirable changes in the existing Tentative Method of Test for Tinting Strength of White Pigments (D 332 – 31 T).[2] In addition, a specification method for tinting strength of white pigments has been issued by the Federation of Paint and Varnish Production Clubs. In an effort to meet the suggestions for change and at the same time to evolve a method that would, to some extent at least, conform to the Federation Method, an extensive revision of the existing tentative method has been prepared and incorporated in the completely modified method, appended hereto,[3] which the subcommittee recommends be accepted and the method as revised continued as tentative.

The subcommittee recommends that the Tentative Method of Test for Comparative Hiding Power of Paints (D 344 – 32 T) be continued as tentative without revision.

Further correspondence with certain laboratories has indicated the desirability of making some additional minor changes in several of the standard methods of analysis. These comprise a tentative revision of the Standard Methods of Routine Analysis of Dry Red Lead (D 49 – 33) proposed for the first time and modifications of tentative revisions proposed in 1932 in the Standard Methods of Routine Analysis of White Linseed Oil Paints (D 215 – 29) and of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 – 27). The subcommittee recommends that the following modifications of these standard methods be accepted for publication as tentative revisions. The tentative revisions of other sections of the two latter standards are to be continued in the form as proposed in the 1932 report.[4]

---

[1] See p. 871.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 797 (1931); also 1933 Book of A.S.T.M. Tentative Standards, p. 525.

[3] See p. 866.—Ed.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 380 and 382 (1932).

Standard Methods of Routine Analysis of Dry Red Lead (D 49 - 33):[1]

Section 6.—Change the procedure for determining Total Lead and Insoluble Matter to read as follows:

6. (*a*) Treat 1 g. of the sample with 15 cc. of HNO_3 (1:1) and sufficient H_2O_2 to dissolve all PbO_2 on warming. If any insoluble matter is present, add 25 cc. of water, boil, filter and wash with hot water. The insoluble matter contains free SiO_2 and should be examined for $BaSO_4$ and silicates, if appreciable. To the original solution or filtrate from insoluble, add 20 cc. of concentrated H_2SO_4 and evaporate to SO_3 fumes; cool, add 150 cc. of water and 150 cc. of 95 per cent ethyl alcohol, let stand *cold* 2 hr., filter on a Gooch crucible, wash with 95 per cent alcohol, dry at 105 to 110 C. and weigh as $PbSO_4$. Calculate to PbO. Red lead is rarely adulterated, but should sample contain soluble barium compounds, the $PbSO_4$ obtained above will contain $BaSO_4$. In this case, precipitate the lead as sulfide from a slightly acid (HCl) solution, dissolve the PbS in hot dilute HNO_3 and determine the lead as sulfate or chromate. If sample contains significant amounts of calcium or magnesium, boil the HNO_3–H_2O_2 solution until all the lead is converted into nitrate and then determine the lead as $PbCrO_4$.

(*b*) If soluble barium, calcium or magnesium are to be determined, precipitate the lead as sulfide from a slightly acid solution (HCl), dissolve the PbS in hot dilute HNO_3 and determine the lead as sulfate. Boil the filtrate from the PbS to expel H_2S, add a little bromine water to oxidize iron (if present) boil to expel bromine and precipitate the barium with a few cubic centimeters of H_2SO_4 (1:3). Filter and weigh as $BaSO_4$. Calculate to BaO or $BaCO_3$. To the filtrate from the $BaSO_4$, add NH_4OH in slight excess, filter off any precipitate of $Fe(OH)_3 + Al(OH)_3$; wash with hot water. Manganese, if present, can be precipitated by adding bromine and NH_4OH and warming; filter, wash with hot water, ignite and weigh as Mn_3O_4. Unite all the filtrates, make slightly acid with acetic acid, heat to boiling and pass H_2S into the hot solution till saturated (20 to 30 minutes); add 5 g. of NH_4Cl and let stand 5 hr.; filter off any ZnS, wash with H_2S water, dissolve the ZnS in hot dilute HCl and determine the zinc by titration with $K_4Fe(CN)_6$. Or, boil off the H_2S, filter out any separated sulfur and determine the zinc as $Zn_2P_2O_7$. Calcium may be determined in the filtrate from the ZnS by expelling H_2S and then adding NH_4OH and ammonium oxalate in the usual manner. Titrate with $KMnO_4$. In the filtrate from calcium determine magnesium in the usual manner by precipitating with sodium-phosphate solution, finally weighing as $Mg_2P_2O_7$.

Standard Methods of Routine Analysis of White Linseed Oil Paints (D 215 - 29):[2]

Under Section (2) Mixed or Composite Pigments, change the procedure for determining *Insoluble Matter* to read as follows:

Insoluble Matter.—Moisten 1 g. of the sample with a few drops of alcohol, cover, add 40 cc. of HCl (1:1), boil gently for 5 to 10 minutes. Wash off cover, evaporate to dryness, and heat at about 150 C. for 30 minutes to 1 hr. to dehydrate the residue. Moisten the residue with 4 cc. of concentrated HCl, allow to stand a few minutes, dilute with 100 cc. of hot water, boil a few minutes, filter hot through paper, wash with hot water (till washings give no test for lead and chlorine). Ignite the paper and residue in a platinum or porcelain crucible, cool, and weigh total insoluble matter (Note 5). (The insoluble matter may be filtered off on a Gooch crucible, washed with hot water, dried at 105 C., cooled, and weighed; then ignited, cooled, and weighed, when it is desired to get the loss on ignition (combined water, organic matter, etc.) of same, or the insoluble matter is not to be further examined.) If the sample contains titanium pigment, practically all of the TiO_2 will be found in the insoluble matter along with $BaSO_4$ and siliceous matter. Should an examination of the insoluble matter be necessary, it is advisable to remove the TiO_2 before proceeding further. The TiO_2 may be removed (or determined on a separate portion) by the method described in Section 9 of the Standard Methods of Routine Analysis of Titanium Pigments (A.S.T.M. Designation: D 186) of the American Society for Testing Materials.[1] After removing the TiO_2, the residue containing siliceous matter and $BaSO_4$ may be ignited to remove the filter. To determine $BaSO_4$, mix the ignited insoluble matter with about ten times its weight of anhydrous sodium carbonate (grinding the mixture in an agate mortar if necessary) and fuse in a covered platinum crucible, heating about 1 hr. Let cool, place crucible and cover in a 200-cc. glazed porcelain casserole,[a] add about 100 cc. of water and heat until the mass is disintegrated. Filter on paper into a 300-cc. glazed porcelain casserole (leaving crucible and cover in the original casserole) and wash the casserole and filter thoroughly with a hot solution of Na_2CO_3 (1 per cent). Place the casserole containing the crucible and cover under the funnel, pierce the filter with a glass rod, and wash the residue into the original casserole by means of a jet of hot water. Wash the paper with hot HCl (1:1) and then with hot water. Remove the crucible and cover. Evaporate the HCl solution to dryness, and heat at about 150 C. for 30 minutes to 1 hr.; moisten the residue with about 10 cc. of concentrated HCl, dilute with 100 cc. of hot water, boil a few minutes, filter hot through paper and wash thoroughly with hot water. Dilute the filtrate to a volume of 300 cc., bring to boiling and add, drop by drop, 5 cc. of H_2SO_4 (1:4). Allow to stand in a warm place an hour or so, filter on a weighed Gooch crucible, wash with hot water, ignite, cool and weigh as $BaSO_4$. Subtract the sum of the percentages of $BaSO_4$ and TiO_2 from the percentage of total insoluble matter and report the result as the percentage of insoluble siliceous matter (Note 6).

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 562.

[2] *Ibid.*, p. 583.

To determine silica, acidify the filtrate from the $BaCO_3$ filtration with HCl, boil to expel CO_2, evaporate to dryness, bake to dehydrate the silica, moisten with HCl, dilute with 100 cc. of hot water, boil and filter through the same paper as was used to recover silica from the $BaCO_3$ portion. Wash thoroughly with hot water and proceed as in a silicate analysis.

If it is desired to look for magnesium, combine this last filtrate with the filtrate from the final $BaSO_4$ separation and test for Al_2O_3 and MgO in the usual way. To recover MgO that may have dissolved in the procedure for the elimination of the TiO_2, make the filtrate containing the TiO_2 just alkaline with NH_4OH, bring to boiling, filter and wash. The filtrate may be tested for

---

[a] A casserole is preferable to a beaker as silica is dissolved from glass when in long contact with a strong sodium carbonate solution.

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 577.

MgO. Any Al_2O_3 present will be precipitated along with the TiO_2. To recover this, ignite and weigh as TiO_2 and Al_2O_3. Deduct for TiO_2 present in the sample; the difference is Al_2O_3.

Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (D 126 – 27):[1]

Change the procedure for determining Total Chromium in the Methods of Analysis of Chrome Oxide Green proposed for incorporation in the standard methods to read as follows:

57. (*a*) *Standard Ferrous Solution.*—Dissolve 39.25 g. of ferrous ammonium sulfate crystals in 950 cc. of distilled water and add 50 cc. of H_2SO_4 (sp. gr. 1.84).

(*b*) *Decinormal Potassium Permanganate Solution.*—Dissolve 3.2 g. of pure $KMnO_4$ and 1 liter of distilled water, let stand 8 to 14 days, siphon off the clear solution (or filter through asbestos), and standardize as follows: In a 400-cc. beaker dissolve 0.20 to 0.25 g. (accurately weighed) of pure potassium pyro chromate, $K_2Cr_2O_7$, crystals in about 300 cc. of water and add 20 cc. of H_2SO_4 (1:1). Add a measured excess of 0.1 *N* $FeSO_4$ solution and titrate back with the $KMnO_4$ solution which is being standardized. Now take the same volume of $FeSO_4$ solution and dilute to 300 cc. and titrate with the $KMnO_4$ solution. The difference between the two titrations represents the ferrous sulfate that was oxidized by the dichromate in terms of cubic centimeter readings of $KMnO_4$. The weight of pure $K_2Cr_2O_7$ divided by the cubic centimeter readings of $KMnO_4$ (by difference) gives the grams of $K_2Cr_2O_7$ equivalent to 1 cc. of $KMnO_4$. One cubic centimeter of the $KMnO_4$ solution should be equal to about 0.00173 g. of chromium.

58. *Procedure.*—Mix thoroughly about 0.25 g. (accurately weighed) of the sample with approximately 5 g. of sodium peroxide (containing at least 90 per cent Na_2O_2) in a 30-cc. pure iron crucible (ordinary iron crucibles may contain some chromium and manganese) and fuse carefully over a gas flame. Five minutes fusion at a low red heat after the mass has melted will insure complete decomposition. Allow the crucible to partly cool, and while tightly covered, tap on an iron plate to loosen the fusion in a solid cake. Place the cake in a covered beaker and dissolve with 200 cc. of warm water. Rinse the crucible and cover with warm water, adding to the main portion. Add approximately 1 g. of sodium peroxide and boil the solution vigorously for 10 minutes, to destroy excess peroxide. If excess peroxide is not destroyed, some of the chromium will be reduced when the solution is acidified. Cool and acidify with sulfuric acid (50 cc., 1:1 sulfuric acid). A clear solution with a few scales of magnetic oxide should result. Immediately cool again, add 5 cc. of phosphoric acid (sirup, sp. gr. 1.7), transfer to an 800-cc. beaker and dilute with cold water to 500 cc. Add an accurately measured excess (about 100 cc.) of approximately 0.1 *N* ferrous ammonium sulfate to the solution while stirring. When reduction is complete a deep pure green color should develop, and a drop of the liquid when tested with a drop of dilute potassium ferricyanide solution should give a blue color. Set the beaker about ½ in. above a white tile to secure good light. Determine the excess of ferrous sulfate by titration with a standard solution (approximately 0.1 *N*) of potassium permanganate. Take

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 617.

the first faint permanent darkening of the clear green color as the end point. Addition of more permanganate increases the depth of the color which finally becomes purple. The end point is quite sharp and well defined, but requires some practice. In exactly the same manner carry through a blank determination, starting with a peroxide fusion. Finally, add the exact volume of ferrous solution as was used in the determination and titrate back with the $KMnO_4$ solution. The difference between the volumes required in the two titrations represents the chromium in the sample and the percentage is found by multiplying this valus by 400 times the chromium titre of the $KMnO_4$ solution.

Respectfully submitted on behalf of the subcommittee,

G. F. A. STUTZ,
Chairman.

REPORT OF SUBCOMMITTEE XIII ON SHELLAC

Subcommittee XIII on Shellac has considered certain suggestions that have been received during the year concerning the specifications for shellac varnish and the methods of testing shellac, under its jurisdiction. The subcommittee is presenting, as given in detail below, certain improvements in the specifications and recommends their adoption as standard. A minor addition is also being made to the standard methods.

Tentative Specifications for Shellac Varnish (D 359 - 33 T).[1]—The subcommittee recommends that these specifications be revised as follows and adopted as standard:

Section 6.—Attention has been called to the fact that the non-volatile matter specified in the case of medium body bleached shellac varnish was exactly half-way between the requirements specified for light body and heavy body varnishes, whereas, for orange shellac varnish this is not the case. The subcommittee believes that the non-volatile matter requirement of the medium body orange shellac varnish should be midway between the requirements for the light and heavy body varnishes and accordingly recommends that in Section 6 the percentage of non-volatile matter for orange medium body varnish be changed from the present requirement of "38.5 per cent" to "38.0 per cent."

Section 7.—Add a note at the end of this section to read as follows:

NOTE.—Since refined bleached shellac varnish is not centrifuged, but in commercial practice is clarified by settling or filter pressing with or without the addition of oxalic acid or other coagulating precipitating medium, therefore this product, known in the trade as White French Varnish, is practically free from wax, alcohol insoluble matter and ash.

Tentative Specifications for Centrifuged Shellac Varnish (D 360 - 33 T).[1]—The subcommittee recommends that these specifications be revised as follows and adopted as standard:

Section 2.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

2. Centrifuged shellac varnish shall be furnished as Orange, Grades A or [B and as Bleached, Grades, "Regular" or "Refined"] *D, and* each [type] *grade* shall be furnished as light, medium, heavy or very heavy, as specified, or any other body mutually agreed upon by the purchaser and seller.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 727, 729 (1933); also 1933 Book of A.S.T.M. Tentative Standards, pp. 500, 502.

Section 6.—Under the tabular heading, Orange Shellac Varnish, change "Grades A or B" to read "Grades A or D." Delete from this section all requirements for Bleached Shellac Varnish, Regular or Refined.

The subcommittee believes that the non-volatile matter requirement of the medium body orange shellac varnish should be half-way between the requirement for the light and heavy body varnishes, as explained under the Tentative Specifications for Shellac Varnish (D 359 – 33 T) above, and accordingly recommends that in Section 6 the percentage of non-volatile matter for orange medium body varnish be changed from the present requirement of "38.0 per cent" to "37.5 per cent."

Section 7.—Under the tabular heading, Orange Shellac Varnish, change "Grade B" to read, "Grade D." Change the maximum percentage of ash for Grade A and the newly designated Grade D from the present value of "1.0 per cent" to "0.30 per cent." Delete from this section all requirements for Bleached Shellac Varnish, Regular or Refined.

Standard Methods of Sampling and Testing Shellac (D 29 – 33).[1]—The subcommittee recommends that in these methods, immediately following the last sentence of the second paragraph of Section 6 which reads: "keep the volume of alcohol constant," the following new paragraph be added as an editorial change:

> Meanwhile place an extracted, weighed cartridge in the filter tube. The hot water around the tube must be maintained at not less than 90 C. Wet the cartridge with hot alcohol, and decant the boiling alcohol-shellac solution into the warm cartridge until the beaker is nearly empty.

Respectfully submitted on behalf of the subcommittee,

J. W. PAISLEY,
Chairman.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 678.

REPORT OF SUBCOMMITTEE XV ON SPECIFICATIONS FOR PIGMENTS DRY AND IN OIL WHEN MARKETED IN THAT FORM

During the past year Subcommittee XV has given further study to two of the existing specifications under its jurisdiction and has written five new proposed tentative specifications.

The Standard Specifications for Pure Linseed Oil Putty for Glazing (D 317 – 33) have been the subject of further extended study with the assistance of numerous specialists among technical and manufacturing interests, but without resulting in agreement on any revision of the specifications.

Last year a tentative revision[1] of the Standard Specifications for Basic Carbonate White Lead (D 81 – 31) was issued which covered a new variety of semipaste containing a small percentage of volatile thinner, and the necessary corresponding editorial changes in other sections. This revision is now recommended for adoption as standard with the following additional change in Section 2 (*a*):

Section 2 (*a*).—Change to read as follows by the omission of the words in brackets:

> 2. (*a*) Dry Pigment.—The pigment [shall be the product made from metallic lead and] shall have a composition corresponding approximately to the formula $2PbCO_3 \cdot Pb(OH)_2$. It [shall be thoroughly washed after corroding,] shall be free from impurities [and adulterants,] and shall meet the requirements given in Section 3 (*a*) and (*b*).

Study of pigments containing titanium dioxide has been progressing intermittently for several years. Three varieties of these pigments are now available commercially under competitive conditions and the industry has reached proportions which merit the adoption of specifications for them. The subcommittee therefore recommends that the following specifications be accepted for publication as tentative as appended hereto:[2]

Tentative Specifications for Titanium Barium Pigment
Tentative Specifications for Titanium Calcium Pigment
Tentative Specifications for Titanium Dioxide

The zinc pigment industry has also been advancing and has developed an improved high strength lithopone and a pure zinc sulfide pigment which have attained important commercial proportions. The subcommittee has accordingly prepared specifications for these materials, the titles of which are as follows, wnich are recommended for publication as tentative as appended hereto:[1]

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 1036 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 1074.

[2] See pp. 856, 858 and 860.—Ed.

Tentative Specifications for Zinc Sulfide
Tentative Specifications for High Zinc Sulfide Lithopone

Respectfully submitted on behalf of the subcommittee,

H. E. SMITH,
Chairman.

---

[1] See pp. 864 and 862.—ED.

REPORT OF SUBCOMMITTEE XXV ON CELLULOSE ESTER COATINGS

Subcommittee XXV on Cellulose Ester Coatings has held one meeting since the June meeting of 1933.

The subcommittee recommends that the following changes be made in the Tentative Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels (D 333 - 33 T)[1] and that the methods as thus revised be continued as tentative:

Section 1.—Revise the test for weight per gallon by changing Paragraphs (*a*) and (*b*) to read as follows by the addition of the italicized words and the omission of those in brackets:

(*a*) The weight in pounds per U. S. gallon shall be obtained by multiplying the specific gravity by 8.32. The specific gravity shall be determined by any convenient method that is accurate to [the second decimal place] ***three significant figures,*** the temperature of both sample and water being 20 C.

(*b*) Mobile Liquids.—For sufficiently mobile liquids a convenient apparatus is an accurately calibrated volumetric flask. [Fill to the mark at 20 C. and weigh accurately. Apply the following equation:]

$$\left[\text{Sp. gr.} = \frac{\text{Weight in grams of contents}}{\text{Capacity in milliliters}}\right]$$

Section 2.—Change the drying time test to read as follows by the addition of the italicized words and the omission of those in brackets:

2. The sample and a mutually agreed upon standard shall be flowed without thinning, crosswise on a clean 4 by 8-in. glass plate, ***in a location free from draft,*** and examined for drying [and hardening] at specified periods such as 3 minutes, 15 minutes, 1 hour and 24 hours. The drying shall be judged by touching or pressing the films with the finger at approximately the same points.

Section 3.—Delete the test for color which reads as follows, changing the section numbers of the remaining sections accordingly:

3. A panel for the color test shall be prepared by pouring the sample and a mutually agreed upon standard on an opaque surface in such a manner that the two materials shall flow together along adjacent edges. The background shall be a mutually agreed upon material. A preliminary examination may be made after 1 hour, but the final examination shall not be made until 24 hours after pouring.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 741 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 518.

Section 4.—Replace the first sentence of the test for gloss which reads as follows:

> The panel prepared for the color test in accordance with Section 3 shall be examined after 24 hours for gloss.

by the following two sentences:

> A panel for the gloss test shall be prepared by pouring the sample and a mutually agreed upon standard on an opaque mutually agreed upon surface in such a manner that the two materials flow together along an adjacent edge. The panel shall be examined for gloss after 24 hr.

The subcommittee has completed the preparation of proposed Tentative Specifications for Amyl Acetate (from Fusel Oil) which are recommended for publication as tentative as appended hereto.[1] The subcommittee also proposes that these specifications, after subsequent adoption as standard, be published with the existing Standard Specifications for Amyl Acetate (Synthetic) (D 318 – 33) under the general title of specifications for amyl acetate.

Subcommittee XXV is responsible for a number of tentative specifications and tests for solvents which are not yet ready for modification or adoption as standard, and the subcommittee accordingly recommends their continuation as tentative.

The proposal of Subcommittee XII on Flash Point, of Committee D-2 on Petroleum Products and Lubricants, that the proposed changes of the Standard Method of Test for Flash Point of Volatile Flammable Liquids (D 56 – 21), published as information in the 1933 report[2] of Subcommittee XXV, appear as footnotes or in an appendix to the present method, meets with the approval of Subcommittee XXV, and the subcommittee urges their adoption. These changes pertain to modifications in the present standard method that are desirable in determining the flash points of the more common lacquer solvents.

Respectfully submitted on behalf of the subcommittee,

R. M. CARTER,
Chairman.

---

[1] See p. 878.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 328 (1933).

REPORT OF COMMITTEE D-2
ON
PETROLEUM PRODUCTS AND LUBRICANTS

Committee D-2 on Petroleum Products and Lubricants held three regular meetings during the past year (in June at Atlantic City, N. J., in January at Detroit, Mich., and in March at Washington, D. C.) and also an informal meeting in October at Chicago, Ill., at the time of the annual meeting of the American Petroleum Institute.

During the year, Subcommittee V on Viscosity and Subcommittee XVII on Viscosity-Temperature Chart were combined in a single subcommittee (Subcommittee V on Viscosity) under the chairmanship of J. C. Geniesse, and the scope broadened to include viscosity-temperature relationships. Two special subcommittees were organized: one on Abridged Volume Correction Table, under the chairmanship of E. W. Dean, and the other on Revision of Report on Significance of Tests of Petroleum Products, under the chairmanship of J. B. Rather.

Acting as Sectional Committee Z11 on Methods of Testing Petroleum Products and Lubricants, functioning under the procedure of the American Standards Association, the following recommendations in connection with American Standards and American Tentative Standards have been made during the year:

Approval of Revision of American Standards:

Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil (D 129 - 33) (A.S.A. No. Z11.13 - 1933)

Method of Test for Cloud and Pour Points (D 97 - 33) (A.S.A. No. Z11.5 - 1933)

Method of Test for Flash and Fire Points by Means of Open Cup (D 92 - 33) (A.S.A. No. Z11.6 - 1933)

Methods of Test for Viscosity of Petroleum Products and Lubricants (D 88 - 33) (A.S.A. No. Z11.2 - 1933)

Approval of A.S.T.M. Standard as American Standard:

Method of Test for Gravity of Petroleum and Petroleum Products by means of the Hydrometer (D 287 - 33) (A.S.A. No. Z11.31 - 1933)

Approval of Revision of American Tentative Standard:

Method of Test for Penetration of Greases and Petrolatum (D 217 - 33 T) (A.S.A. No. Z11.3 - 1933)

Approval of Advancement of American Tentative Standards to American Standards

Method of Test for Dilution of Crankcase Oils (D 322 - 33) (A.S.A. No. Z11.29 - 1933)

Method of Test for Precipitation Number of Lubricating Oils (D 91 - 33) (A.S.A. No. Z11.30 - 1933)

These recommendations have been approved by the American Standards Association with A.S.A. numbers as indicated.

An organization meeting of the technical committee on Nomenclature and Methods of Testing Petroleum Products and Lubricants of the International Standards Association (I.S.A. Technical Committee No. 28) was held in London, July 22, 1933, in connection with the World Petroleum Congress, with an attendance of forty-six delegates representing eleven countries. At this meeting it was agreed that, upon completion of a distribution of the national standards in effect in the countries represented on the committee to all committee members, suggestions would be sent to the secretariat for the future program of the committee; and that a dictionary of terms used in the testing of petroleum be developed in English, French, and German. The committee also expressed approval of the expression of viscosity in absolute units. This proposal is under discussion in this country and has not yet received the approval of the American Standards Association.

Acting on the recommendation of Committee D-2, Committee E-10 on Standards on January 30, 1934, accepted the Method of Test for Gum Content of Gasoline (D 381 - 34 T)[1] for publication as tentative.[2]

The voting membership of Committee D-2 now consists of 41 producer, 31 consumer and 12 general interest members.

ACTIVITIES OF SUBCOMMITTEES AND TECHNICAL COMMITTEES

Appended hereto is the report of Technical Committee A on Gasoline.

Subcommittee I on Corrosion Test for Lubricating Oils (H. C. Mougey, chairman) is investigating various corrosion tests on different types of lubricants as a first step in its work.

Subcommittee VIII on Distillation (E. W. Dean, chairman) is attempting to develop a vacuum distillation method. In its work to date, four existing methods have been studied.

Subcommittee XII on Flash Point (J. B. Terry, chairman) has been working on a method for the more accurate measurement of the flash point of viscous liquids, especially cut-back asphalts and suspensions of solids, than is now possible with any of the three standard methods, namely, the open cup method (D 92), the Pensky-Martens closed tester (D 93) and the Tag closed tester (D 56). The subcommittee has developed a modification of the Standard Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (D 93 – 22) to permit of a better control of the rate of heating and a rapid, continuous stirring of the material being tested. The following is the proposed procedure which is published at this time for information with the ultimate object of incorporating it as a note or an appendix to Method D 93 – 22:

---

[1] See p. 899.—ED.

[2] In submitting this tentative method to Committee E-10 on Standards, the committee reported the results of the letter ballot as follows: 52 members returned their ballots, of whom 49 voted affirmatively, 1 negatively and 2 refrained from voting.

DETERMINATION OF FLASH POINT OF VISCOUS MATERIALS AND SUSPENSIONS OF SOLIDS BY MEANS OF THE PENSKY-MARTENS CLOSED TESTER

1. *Apparatus.*—The apparatus shall consist of the following:

(*a*) *Flash Point Tester.*—Pensky-Martens flash cup with cover and stirring device conforming to the requirements prescribed in the Standard Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (A.S.T.M. Designation: D 93) of the American Society for Testing Materials,[1] except that the stirrer shall be mechanically operated to stir in a downward direction at a speed of 70 to 80 r.p.m.

(*b*) *Thermometer.*—Pensky-Martens Low Range "A.S.T.M., P.M. and Tag" Thermometer conforming to the requirements prescribed in Table I of Section 2 (*d*) of the Standard Method D 93.[1]

2. *Procedure.*—The material to be tested and the tester shall be brought to a temperature 30 F. lower than the expected flash point. The air space between the cup and the interior of the air bath shall be completely filled with water at the same temperature as the tester and material. The temperature shall be raised throughout the duration of the test at a rate of not less than 4 nor more than 6 F. per minute. With the exception of the stirrer operating at 70 to 80 r.p.m. and the heating rate as specified above, the procedure shall be the same as that prescribed in the Standard Method of Test for Flash Point of Volatile Flammable Liquids (A.S.T.M. Designation: D 56) of the American Society for Testing Materials.[2]

3. *Accuracy.*—Duplicate tests should not differ by more than 5 F.

Special Subcommittee on Revision of Report on Significance of Tests of Petroleum Products has completed its assignment and the proposed revision and amplification of the discussion on significance of tests has been approved by the committee. The second edition of the report will soon be published.[3]

Technical Committee C on Fuel Oils (Including Diesel Fuel) (Lee Schneitter, chairman).—Section I on Domestic and Industrial Fuel Oil (H. C. Dickinson, chairman) held a meeting in March to discuss changes in the Commercial Standard for Fuel Oils (CS 12 – 33) proposed by a special subcommittee cooperating with representatives of the Technical Committee on Lubricants and Liquid Fuels of the Federal Specifications Board. The recommendations resulting from this meeting will be circulated for letter ballot of Technical Committee C and Committee D-2 and, if approved, will be transmitted to the National Bureau of Standards for revision of the commercial standard.[1]

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 805.

[2] *Ibid.*, p. 663.

[3] Issued, September, 1934.—ED.

The Executive Committee of Technical Committee C at a meeting in December, 1933, authorized the formation of a working subcommittee of Section II on Diesel Fuel to collect and correlate the data from all groups working on this subject and to develop tentative specifications for diesel fuels. As a preliminary step in this program, a classification for diesel fuel oils has been prepared and is published for information as an Appendix to this report.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Revision of Standards:

The committee recommends the revision of two standard methods, as indicated below, to become effective immediately. It accordingly asks for the necessary nine-tenths vote at the annual meeting in order that these revisions may be submitted to letter ballot of the Society.

Standard Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil (D 129 - 33).[2]—The following minor changes are recommended by Subcommittee VII on Sulfur Determination (H. M. Hancock, chairman) to provide a statement on scope and to amplify the section on accuracy:

Title.—Change the title to read as follows by the addition of the italicized words and the omission of those in brackets:

Standard Method of Test for Sulfur in Petroleum Oils [Heavier than Illuminating Oil] *by Bomb Method.*

Scope.—Add a new Section 1 on Scope to read as follows, renumbering the present sections accordingly:

1. This method shall be used for the determination of sulfur in petroleum oils which cannot be burned completely in a wick lamp.

Section 6.—Change from its present form: namely,

6. For oils having a sulfur content of 0.5 per cent or greater, duplicate determinations should agree within ±2 per cent.

to read as follows:

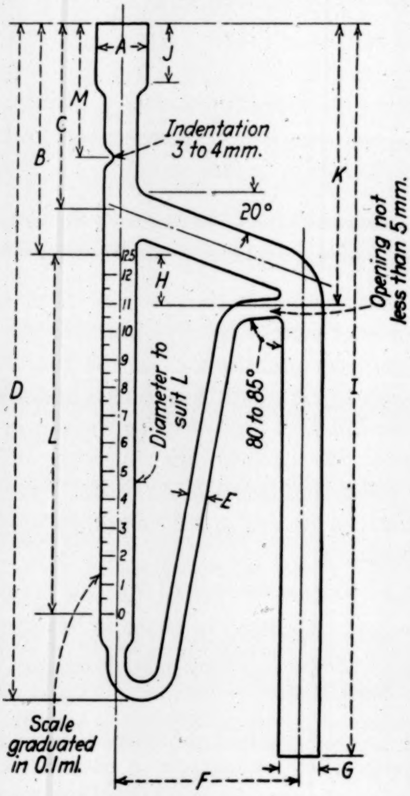
6. The percentages of sulfur obtained by the same operator with the same apparatus should not differ by more than $0.02 + 0.04A$; while the percentages obtained by different operators in different laboratories should not differ by more than $0.02 + 0.08A$. (A represents the average of the percentages obtained.)

---

[1] At the annual meeting it was agreed to recommend to Committee E-10 on Standards, subject to approval by letter ballot of Committee D-2, that the revision of the fuel oil specifications be published as tentative specifications by the Society. (See Editorial Note on p. 434.)

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 872.

Standard Abridged Volume Correction Table for Petroleum Oils (D 206 - 25).[1]—The Special Subcommittee on Abridged Volume Correction Table (E. W. Dean, chairman) has recommended that the standard table be revised, as appended hereto,[2] by the addition of two new groups, one for light and the other for heavy products. The tabular material has also been rearranged for convenience in use.


A
J
M
C
B
Indentation 3 to 4mm.
K
20°
Opening not less than 5 mm.
12.5
12
H
11
10
9
8
7
6
5
4
3
2
1
0
Diameter to suit L
80 to 85°
D
L
E
I
Scale graduated in 0.1ml.
F
G

A	18 to 20 mm., inside diameter	*H*	15 to 20 mm.
B	85 to 90 mm.	*I*	270 to 290 mm.
C	70 to 75 mm.	*J*	25 to 30 mm.
D	240 to 260 mm.	*K*	100 to 110 mm.
E	4 to 5 mm., inside diameter	*L*	125 to 138 mm.
F	65 to 75 mm.	*M*	40 to 50 mm.
G	11 to 15 mm., inside diameter		

FIG. 1.—A.S.T.M. Dilution Trap for Testing Crankcase Oils.

The committee recommends the following changes in four standard methods for publication as tentative revisions and editorial changes in two standards:

---

[1] **1933 Book of A.S.T.M. Standards, Part II, p. 886.**

[2] The revised volume correction table was adopted as standard and appears in the 1934 Supplement to Book of A.S.T.M. Standards, p. 127.

Standard Method of Test for Dilution of Crankcase Oils (*D 322 - 33*).[1]—On the recommendation of Committee D-15 on Thermometers and Laboratory Glassware and Subcommittee XXV on Crankcase Dilution (T. H. Rogers, chairman) it is proposed that for convenience in manufacture of the dilution trap the present Fig. 1 illustrating this piece of apparatus be replaced by a new figure as shown in the accompanying Fig. 1.

Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (*D 86 - 30*).[2]—The following minor change in this method is recommended by Subcommittee VIII on Distillation (E. W. Dean, chairman) to clarify the wording:

Section 8 (*d*).—Make the footnote referred to in this paragraph a note to appear after Paragraph (*d*) and change it to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

> NOTE.—For products having end points not higher than 482 F. (250 C.) or initial boiling points not higher than 212 F. (100 C.), the Low-Distillation Thermometer shall be used; for [all other] products *having end points higher than 482 F.* (*250 C.*) *and initial boiling points higher than 212 F.* (*100 C.*) the High-Distillation Thermometer shall be used.

Standard Method of Test for Precipitation Number of Lubricating Oils (*D 91 - 33*)[3] and *Standard Method of Test for Water and Sediment in Petroleum Products by Means of Centrifuge* (*D 96 - 30*).[4]—The following addition to these methods is recommended respectively by Subcommittee IX on Precipitation (L. W. Parsons, chairman) and Subcommittee XIV on Water and Sediment (H. R. Gundlach, chairman):

Section 4.—Between the present third and fourth sentences of this section add a new sentence to read as follows:

> Air-free distilled water at 20 C. (68 F.) shall be used for the calibration of tubes.

Standard Method of Test for Distillation of Crude Petroleum (*D 285 - 33*).[5]—Since the flask employed in this test holds 500 ml., it is proposed to delete reference to the size of the flask in order to avoid misunderstanding. Editorial changes as indicated below are accordingly recommended by Subcommittee XXI on Crude Petroleum (A. J. Kraemer, chairman) in this standard method:

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 768.

[2] *Ibid.*, p. 778.

[3] *Ibid.*, p. 842.

[4] *Ibid.*, p. 895.

[5] *Ibid.*, p. 771.

Section 2.—Change the first sentence to read as follows by the addition of the italicized words and the omission of the words and figures in brackets:

> 2. Flask.—The distillation flask shall be [a 300-ml. Hempel distilling flask] *of the type illustrated in* Fig. 1, the dimensions and allowable tolerances being as follows:

Figure 1.—Change the caption under Fig. 1 from "Dimensions of 300-ml. Hempel Flask" to read "Distillation Flask."

Section 9 (d).—Change the first sentence of this paragraph to read as follows by the addition of the italicized word and the omission of the word in brackets:

> A 300-ml. sample of the oil shall be measured into the [Hempel] *distillation* flask by any suitable means.

Standard Methods of Sampling Petroleum and Petroleum Products (D 270 - 33).[1]—The following editorial changes in these methods are recommended by Subcommittee XV on Sampling and Gaging (A.E. Flowers, chairman) in order to eliminate certain minor discrepancies between them and the Standard Methods of Testing Electrical Insulating Oils (D 117 - 33):

Section 56.—In the note following this section change the third sentence to read as follows by the addition of the italicized words:

> Samples placed in glass bottles shall be kept in the dark if subsequent testing is to include color and sludge-forming characteristics or neutralization values *as light produces changes in these properties.*

Section 59.—In the note following Paragraph (*a*) of this section change the fifth sentence to read as follows by the omission of the words in brackets:

> Bottles or containers shall be so handled that the operator's fingers never touch the lip [, and a portion of the sample shall be poured over the lip and thrown away before pouring the sample into the testing apparatus].

Section 60.—Delete from this section the note which reads as follows:

> NOTE.—Instead of empty sample containers the operator may carry along containers filled with clean tested oil which may be poured into the top of the apparatus to compensate for the quantity removed.

II. Proposed Revision of Tentative Standards:

The committee recommends the revision of the following five tentative methods as indicated:

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 846.

Tentative Method of Test for Color of Lubricating Oils by Means of A.S.T.M. Union Colorimeter (D 155 – 32 T),[1] and *Tentative Method of Test for Color of Petrolatum by Means of A.S.T.M. Union Colorimeter (D 218 – 32 T)*.[1] The following changes are recommended by Subcommittee VI on Color (H. M. Hancock, chairman) to provide a more complete description of the lamp, filter, reflector and opal glass:

Section 2 (c).—Change the fourth and fifth sentences from the end of this paragraph, describing the white opal glass, to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> A [pure white] *flashed* opal glass approximately $3\frac{1}{4}$ by $1\frac{3}{4}$ by $\frac{1}{16}$ in. (82 by 44 by 1.5 mm.) shall be mounted across the illumination end of the box. [The glass shall be ground or etched on the inner side to diffuse light rays.] *This glass, used as an intercepting light diffuser, shall be especially selected to be free from bubbles and other imperfections, shall be uniform as to density and thickness of the opal flash, and particularly shall be of such integral color as to result in minimum selective absorption.*

Section 2 (g).—Change this paragraph from its present form to read as follows:

> (*g*) The artificial daylight lamp assembly, *c*, Fig. 1, may for convenience be fastened to the base supporting the box and shall consist of a lamp and socket, a reflector and a daylight filter glass. The lamp shall be a 60-watt Mazda, A21 bulb, clear glass, inside frost finish, maintained at 12.3 lumens per watt, furnishing light at a color temperature of approximately 2750°K. The lamp shall be fitted into a socket equipped with a reflector, hemispherical in form, the interior surface of which shall be finished with a brilliant aluminum-bronze powder, free from mica and other adulterants, applied with a heat-resisting bronzing liquid, sprayed uniformly over the surface. This finish shall be such as to be free from selective absorption and have an initial reflectivity above 65 per cent. A daylight filter glass, concave-convex in form, shall be closely fitted over the opening in the hemispherical reflector and attached in such a manner as to be dust tight. The glass shall be finished on its concave surface, by sand-blasting and acid-smoothing or fortifying. When in normal position the near surface of the daylight filter shall be 4 in. (102 mm.) from the flashed opal glass.
>
> NOTE.—A spectrophotometric test of an acceptable filter shall indicate a transmission of radiant energy not less than 60 per cent at 410 $m\mu$ with a smooth curve down to a transmission below 10 per cent at 700 $m\mu$. This curve, furthermore, shall be without the pronounced hump which is characteristic of excess cobalt, the typical cobalt curve having an increased transmission at wave length of 570 $m\mu$ above a straight line drawn between the points 540 $m\mu$ and 590 $m\mu$, and also a transmission band in the red for wave lengths of 660 $m\mu$ and greater. This variation in an acceptable filter may not at 570 $m\mu$ exceed 0.03 above the straight line drawn between 540 $m\mu$ and 590 $m\mu$, nor shall the

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, pp. 747, 752 (1932); also 1933 Book of A.S.T.M. Tentative Standards, pp. 527, 532.

transmission for wave length 700 mμ exceed the transmission for any shorter wave length such as 660 mμ by more than 0.03.

An acceptable daylight filter shall also possess such characteristics that the trilinear coordinates x, y, and z, and the luminous transmission T_w, when calculated from the spectral transmission data using the 1931 I.C.I.[a] Standard Illuminant *A*[b] shall be as follows:

T_w	0.107 to 0.160
x	0.314 to 0.330
y	0.337 to 0.341
z	0.329 to 0.349

The artificial daylight lamp shall be used for referee work. When electric current is not available, the colorimeter may be used by exposing the illumination end to northern daylight provided there are no colored objects in the immediate foreground.

---

[a] International Commission on Illumination.

[b] Dorothy B. Judd, "The 1931 I.C.I. Standard Observer and Coordinate System for Colorimetry," *Journal*, Optical Soc. America, Vol. 10, p. 365, October, 1933.

Figure 1.—Change the shape of the reflector to a hemispherical form to conform to the change in the text.

Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (D 156 – 23 T).[1]—The following changes are recommended by Subcommittee VI on Color (H. M. Hancock, chairman) to provide a more complete description of the lamp, filter, reflector, opal glass and color standards:

Section 2 (b).—Change the last sentence of this paragraph to read as follows by the addition of the italicized words:

> The arrangement shall be such as to provide a circular field of vision *free from distortion and parallax*, the two halves of which are illuminated by the light transmitted by the sample and the color standard, respectively.

Section 3.—Change Paragraphs (*b*) and (*c*) from their present form to read as follows:

> (*b*) The light shall be supplied by an artificial daylight lamp so arranged as to project a diffused light with the absence of glare or shadow on the reflecting mirror or directly up through the tubes. Light from all other sources shall be excluded.
>
> (*c*) The artificial daylight lamp assembly shall consist of a lamp and socket, a reflector and a daylight filter glass. The lamp shall be a 60-watt Mazda, A21 bulb, clear glass, inside frost finish, maintained at 12.3 lumens per watt, furnishing light at a color temperature of approximately 2750°K. The lamp shall be fitted into a socket equipped with a reflector, hemispherical in form, the interior surface of which shall be finished with a brilliant aluminum bronze powder, free from mica and other adulterants, applied with a heat-resisting

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 682 (1923); also 1933 Book of A.S.T.M. Tentative Standards, p. 537.

bronzing liquid, sprayed uniformly over the surface. This finish shall be such as to be free from selective absorption and have an initial reflectivity above 65 per cent. A daylight filter glass, concave-convex in form, shall be closely fitted over the opening in the hemispherical reflector and attached in such a manner as to be dust tight. The glass shall be finished on its concave surface, by sandblasting and acid-smoothing or fortifying.

Note.—A spectrophotometric test of an acceptable filter shall indicate a transmission of radiant energy not less than 60 per cent at 410 mμ with a smooth curve down to a transmission below 10 per cent at 700 mμ. This curve, furthermore, shall be without the pronounced hump which is characteristic of excess cobalt, the typical cobalt curve having an increased transmission at wave length of 570 mμ above a straight line drawn between the points 540 mμ and 590 mμ, and also a transmission band in the red for wave lengths of 660 mμ and greater. This variation in an acceptable filter may not at 570 mμ exceed 0.03 above the straight line drawn between 540 mμ and 590 mμ, nor shall the transmission for wave length 700 mμ exceed the transmission for any shorter wave length such as 660 mμ by more than 0.03.

An acceptable daylight filter shall also possess such characteristics that the trilinear coordinates x, y, and z, and the luminous transmission T_w, when calculated from the spectral transmission data using the 1931 I.C.I.[a] Standard Illuminant A[b] shall be as follows:

T_w	0.107 to 0.160
x	0.314 to 0.330
y	0.337 to 0.341
z	0.329 to 0.349

---

[a] International Commission on Illumination.

[b] Dorothy B. Judd, "The 1931 I.C.I. Standard Observer and Coordinate System for Colorimetry,.' *Journal*, Optical Soc. America. Vol. 10, p. 365, October, 1933.

The artificial daylight lamp shall be used for referee work. When electric current is not available, the chromometer may be used by exposing the mirror to northern daylight provided there are no colored objects in the immediate foreground.

Section 4.—Change from its present form: namely,

4. The color standards shall consist of suitable glass disks.

to read as follows:

4. The color standards shall consist of glass disks and one-half disks of such colorimetric characteristics that the trilinear coordinates x, y and z, and the luminous transmission T_w, when calculated from the spectral transmission data using the 1931 I.C.I.[a] Standard Illuminant C[b] shall be as follows:

	WHOLE DISKS	ONE-HALF DISKS
T_w	0.860 to 0.865	0.888 to 0.891
x	0.342 to 0.350	0.327 to 0.331
y	0.367 to 0.378	0.344 to 0.350
z	0.272 to 0.291	0.319 to 0.330

---

[a] International Commission on Illumination.

[b] Dorothy B. Judd, "The 1931 I.C.I. Standard Observer and Coordinate System for Colorimetry." *Journal*, Optical Soc. America, Vol. 10, p. 365, October, 1933.

Table I.—Add to the present Table I the following tabulation covering Saybolt chromometer color for one-half disks corresponding to various depths of oil:

NUMBER OF DISKS	DEPTH OF OIL, IN.	COLOR
One-half	20.00	+30
One-half	18.00	+29
One-half	16.00	+28
One-half	14.00	+27
One-half	12.00	+26

Section 5.—Delete the present Paragraph (*a*) which reads as follows:

(*a*) The Saybolt Chromometer shall be assembled and the light source so adjusted that a diffused light, with absence of glare or shadow, shall be projected on the reflecting mirror, or projected directly through the tubes from the base of the instrument, thereby eliminating the mirror. Light from all other sources shall be excluded.

Combine and change the present Paragraphs (*b*) and (*c*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

[(b)] *5.* The oil tube shall be [cleaned] *cleansed* by rinsing with some of the oil to be tested, care being taken to allow the tube to drain thoroughly. The pet-cock on the oil tube shall then be closed and the tube shall be filled with the oil to be tested to a height of [10.5] *12* in. *If at this depth the color of the oil is lighter than one-half disk, the one-half disk shall be used for the test. If it is darker, the oil level shall be lowered to 10.5 in. and the color compared to two disks. If the color of the oil is lighter than two disks, one disk shall be used and if darker, two disks shall be used.* [(c) The measurement of the color shall be made by using two standard color disks when the oil is darker than the two disks and by using one disk when the oil is lighter than the two disks.] After determining the number of disks to be used and with the proper number in place, [in the color standard] *the level in* the oil tube shall [contain a sufficient height of oil for] *be raised if necessary until* the color of the oil [to be] *is* decidedly darker than the color standard, [additional oil being added if necessary]. The oil shall then be drawn off slowly by means of the pet-cock until the oil appears slightly darker than the color standard. The oil shall then be drawn down to the nearest height corresponding to a standard color shade as shown in Table I. If the color of the oil observed through the eyepiece is still darker than the color standard, the oil shall be drawn down to the next height given in Table I and examined again. This operation shall be continued until the oil and color standard match or show questionable differences. The column of oil shall be lowered one shade more and if the oil is unmistakably lighter than the color standard, the previous color shade shall be recorded as the Saybolt Chromometer Color.

Tentative Method of Test for Knock Characteristics of Motor Fuels (*D 357 - 33 T*).[1]—The following revisions of this method are recommended by Technical Committee A on Gasoline (H. L. Horning, chairman) in order to simplify and improve control:

Section 3.—Change Paragraphs (*l*), (*n*) and (*p*) of this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> (*l*) Oil Heater *and Thermometer.*—Electric heater in base to bring oil to operating temperature quickly, *and a thermometer on the instrument panel to indicate when equilibrium temperature has been reached.*
>
> (*n*) Carburetor.—A special C.F.R. carburetor is furnished with the engine, and can be obtained with either two or [four] *three* float bowls. The carburetor has a fixed fuel jet [shrouded by a variable air jet], *and each float bowl is individually adjustable for level with respect to the jet for varying mixture ratio.* Fuel containers are furnished with the carburetor.
>
> NOTE.—*The use of knock testing apparatus equipped with the carburetor described in the 1933 edition* (*D 357 - 33 T*) *of the method is permissible.*
>
> (*p*) Instruments.—Knock intensity is measured by a bouncing pin, in conjunction with [either] a knockmeter [or a gas-evolution burette]. (The knockmeter is a damped hot-wire ammeter which indicates the effective current in the circuit, thus permitting instantaneous readings.) Current is supplied from a small direct-current generator, belt-driven from the power-absorbing unit. [The gas-evolution burette is an electrolytic cell which integrates the impulses of current through the bouncing-pin circuit and indicates the total by the volume of gas collected in the burette in a given time.]

Section 8.—Delete from the next to the last sentence of the first paragraph the phrase "or from the gas-evolution burette, whichever is used."

Change the first sentence of the second paragraph to read as follows by the addition of the italicized words and the omission of those in brackets:

> For subsequent tests on fuel samples the compression ratio shall be set to duplicate [this] *the* knock intensity as [indicated by the knockmeter or the gas-evolution burette] *recorded above,* provided no change has been made in the bouncing-pin adjustment in the meantime.

Section 9.—Change the last sentence of the first paragraph to read as follows by the omission of the words in brackets; also delete the footnote:

> The knock intensity shall be measured by a bouncing-pin indicator in conjunction with [either] a knockmeter [or a gas-evolution burette].

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 746 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 540.

Section 10.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

10. Using the fuel whose knock rating is to be determined, the carburetor shall be adjusted as follows: After one float bowl of the carburetor has been filled with the fuel of which the octane number is to be determined, adjustment shall be made to obtain maximum knock by [noting the needle-valve micrometer-setting and the knockmeter reading or gas evolution, then turning the micrometer screw] *raising and lowering the level of the float bowl* and noting whether the knockmeter reading [or gas evolution] increases or decreases. The [micrometer] *float bowl* shall then be [turned] *moved* in the direction in which the knock increases until the knock passes through a maximum. This point shall be checked three times and the [micrometer] *float bowl* set at the position of maximum knock. [(*a*) By Knockmeter.—When using the knockmeter, it is unnecessary to take readings over a fixed period of time, but] The knockmeter needle shall be allowed to reach equilibrium after each adjustment of the [micrometer] *float-bowl level.*

[(*b*) By Gas-Evolution Burette.—At least two readings, agreeing within 5 per cent, of the volume of gas evolved over a period of 1 minute shall be taken as a measure of knock intensity.]

Section 11.—Delete the phrase "or the gas-evolution burette."

Section 12.—Change "micrometer" to "level" in the last sentence.

Section 13.—Change the first paragraph to read as follows by the omission of the words in brackets:

With the carburetor [micrometers] set for the air-fuel ratio of maximum knock, alternate series of readings of knock intensity shall be taken on the fuel under test and on a reference fuel blend. [When using] The knockmeter [the] needle shall be allowed to reach equilibrium before the final reading is recorded. [When using the gas-evolution burette, at least two successive 1-min. readings shall agree within 5 per cent.]

Tentative Method of Test for Sulfur in Motor Fuels, Naphthas and Illuminating Oils (Lamp Method) (D 90 - 30 T).[1]—The following minor changes in title and scope are recommended by Subcommittee VII on Sulfur Determination (H. M. Hancock, chairman):

Title.—Change the title to read as follows by the addition of the italicized words and the omission of those in brackets:

Tentative Method of Test for Sulfur in [Motor Fuels, Naphthas and Illuminating] *Petroleum* Oils *by* Lamp Method.

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1134 (1930); also 1933 Book of A.S.T.M. Tentative Standards, p. 564.

1. This method [is intended to cover] *shall be used for* the determination of sulfur in [gasolines and other volatile motor fuels, in illuminating oils, and in petroleum naphthas. It is not strictly applicable to mixtures containing carbon bisulfide] *kerosine, petroleum naphtha, and other petroleum oils which can be burned completely in a wick lamp. This method may be applied to motor fuels which are mixtures of gasoline and volatile non-petroleum oils.*

NOTE.—When this method is applied to mixtures containing carbon bisulfide, approximately 85 per cent of the sulfur present as carbon bisulfide is usually determined.

III. Adoption of Tentative Revision of Standard as Standard:

The committee recommends the submission of a tentative revision in one standard method to letter ballot of the Society for adoption as standard, as follows:

Revision of Standard Method of Test for Cloud and Pour Points (D 97 - 33).[1]—The tentative revision presented in the report of the committee for 1933[1] with further modifications recommended by Subcommittee XVI on Cloud and Pour Test (J. B. Rather, chairman) to define the bath temperatures more closely and to clarify the meaning is recommended for adoption as standard. The complete revision follows:

Section 9.—Change this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets. No change is proposed in the note following this section.

9. The cooling bath, g, shall be of a type suitable for obtaining the required temperatures. The size and shape of the bath are optional but a support, suitable for holding the jacket firmly in a vertical position, is essential. [For determination of very low pour points, a smaller insulated cooling bath may be used and the test jar placed directly in it.] *For determination of pour points below 50 F. two or more baths should be at hand.* The required bath temperatures may be maintained by refrigeration if available, otherwise by suitable freezing mixtures.

Section 10.—Change the fifth and sixth paragraphs of Section 10 to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

[The temperature of the cooling bath, g, shall be adjusted so that it is below the cloud point of the oil by not less than 15 nor more than 30 F. and this temperature shall be maintained throughout the test.] *The temperature of the cooling bath, g, shall be maintained at 30 to 35 F.* The jacket containing the test jar shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

At each test thermometer reading which is a multiple of 2 F., the test jar shall be removed from the jacket, quickly but without disturbing the oil, inspected for cloud, and replaced in the jacket. This complete operation shall require not more than three seconds. [If the oil does not show a cloud when it has been cooled to 15 F., the test jar shall be placed directly in a cooling bath of suitable temperature.] *If the oil does not show a cloud when it has been cooled to 50 F., the test jar shall be placed in a second bath maintained at a temperature of 0 to +5 F. If the oil does not show a cloud when it has been cooled to 20 F. the test jar shall be placed in a third bath maintained at a temperature of −30 to −25 F.*

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 761.

Section 11.—Change the sixth and seventh paragraphs of Section 11 to read as follows by the addition of the italicized words and figure and the omission of those in brackets:

[The temperature of the cooling bath, g, shall be adjusted so that it is below the pour point of the oil by not less than 15 nor more than 30 F. and this temperature shall be maintained throughout the test.] *The temperature of the cooling bath, g, shall be maintained at 30 to 35 F.* The jacket, containing the test jar, shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

Beginning at a temperature 20 F. before the expected pour point, at each test thermometer reading which is a multiple of 5 F., the test jar shall be removed from the jacket carefully and shall be tilted just enough to ascertain whether there is a movement of the oil in the test jar. The complete operation of removal and replacement shall require not more than 3 seconds. [If the oil has not ceased to flow when its temperature has reached 15 F., the cold test jar shall be placed directly in a cooling bath of suitable temperature.] *If the oil has not ceased to flow when its temperature has reached 50 F., the test jar shall be placed in the jacket in a second bath maintained at a temperature of 0 to +5 F. If the oil has not ceased to flow when its temperature has reached 20 F., the test jar shall be placed in the jacket in a third bath maintained at a temperature of −30 to −25 F. For determinations of very low pour points, additional baths should be maintained with successively lower temperature differentials of about 30 F. In each case the test jar shall be transferred when the temperature of the oil reaches a point 50 F. above the temperature of the new bath. At no time shall the cold test jar be placed directly in the cooling medium.* As soon as the oil in the test jar does not flow when the jar is tilted, the test jar shall be held in a horizontal position for exactly 5 seconds, as noted by a stop watch or other accurate timing device, and observed carefully. If the oil shows any movement under these conditions, the test jar shall be immediately replaced in the jacket [if the temperature of the oil is above 15 F., or directly in the cooling bath if the temperature is below 15 F.,] and a test for flow repeated at the next temperature 5 F. lower.

IV. Tentative Standards Continued as Tentative:

The following three tentative standards under the jurisdiction of the committee have been tentative for a period of three years or longer without revision for the reasons indicated:

Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (*D 188 – 27 T*).—Subcommittee XIII on Neutralization Number and Saponification (E. B. McConnell, chairman) now has under way a very extensive test program which will result either in a revision of the present method or in replacing the method with an entirely new one. The subcommittee therefore feels that no changes should be made until the results of this test program are available.

Tentative Method of Test for Expressible Oil and Moisture in Paraffin Waxes (D 308 – 29 T).—This method is a highly empirical one and has not had a sufficiently long period of trial to justify its adoption because of its infrequent use. Subcommittee III on Paraffin Wax (J. B. Rather, chairman) accordingly recommends its continuation as tentative.

Tentative Definitions of Terms Relating to Petroleum (D 288 – 31 T).—Subcommittee XX on Nomenclature (H. E. Miller, chairman) is considering a modification of the definitions of terms relating to petroleum, and it is accordingly desirable to continue them as tentative.

The election of officers resulted in the selection of the present incumbents for the ensuing term of two years.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 84 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF STANDARDS			
Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil (D 129 – 33), immediate adoption	56	0	3
Abridged Volume Correction Table for Petroleum Oils (D 206 – 25), immediate adoption	57	0	2
Test for Dilution of Crankcase Oils (D 322 – 33)	57	0	2
Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 – 30)	55	0	4
Test for Precipitation Number of Lubricating Oils (D 91 – 33)	59	0	0
Test for Water and Sediment in Petroleum Products by Means of Centrifuge (D 96 – 30)	54	1	4
Test for Distillation of Crude Petroleum (D 285 – 33), editorial revision	54	1	4
Methods of Sampling Petroleum and Petroleum Products (D 270 – 33), editorial revision	67	0	3
II. PROPOSED REVISION OF TENTATIVE STANDARDS			
Test for Color of Lubricating Oils by Means of A.S.T.M. Union Colorimeter (D 155 – 32 T)	51	0	8
Test for Color of Petrolatum by Means of A.S.T.M. Union Colorimeter (D 218 – 32 T)	50	1	3
Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (D 156 – 23 T)	50	0	9
Test for Knock Characteristics of Motor Fuels (D 357 – 33 T)	53	1	16
Test for Sulfur in Motor Fuels, Naphthas and Illuminating Oils (Lamp Method) (D 90 – 30 T)	54	0	5
III. ADOPTION OF TENTATIVE REVISION OF STANDARD AS STANDARD			
Test for Cloud and Pour Points (D 97 – 33), as revised	56	1	2

This report has been submitted to letter ballot of the committee, which consists of 84 members; 59 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

T. A. BOYD,
Chairman.

R. P. ANDERSON,
Secretary.

EDITORIAL NOTE

The revisions proposed for immediate adoption in the Standard Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil and in the Abridged Volume Correction Table for Petroleum Oils were unanimously approved at the annual meeting and were subsequently adopted by letter ballot of the Society on September 1, 1934. The method and table in their revised forms appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 124 and 127, respectively. The proposed tentative revisions of the Standard Methods of Test for Dilution of Crankcase Oils, Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products, Test for Precipitation Number of Lubricating Oils and Test for Water and Sediment in Petroleum Products by Means of Centrifuge were accepted for publication as tentative and appear on pages 1272 and 1273. Editorial changes in the Standard Method of Test for Distillation of Crude Petroleum and Methods of Sampling Petroleum and Petroleum Products, the latter proposed on the floor of the annual meeting, see Summary of Proceedings, page 8, were also approved.

The proposed revisions of the Tentative Methods of Test for Color of Lubricating Oils by Means of A.S.T.M. Union Colorimeter, Test for Color of Petrolatum by Means of A.S.T.M. Union Colorimeter, Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer and Test for Sulfur in Motor Fuels, Naphthas and Illuminating Oils (Lamp Method) were accepted. The methods as revised appear on pages 885, 890, 895 and 911, respectively. Revisions of the Tentative Method of Test for Knock Characteristics of Motor Fuels, proposed on the floor of the annual meeting, see Summary of Proceedings, page 8, were accepted. The method in its revised form appears on page 902.

The tentative revision of the Standard Method of Test for Cloud and Pour Points, as revised, was unanimously approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1934. The method in its revised form appears in the 1934 Supplement to Book of A.S.T.M. Standards, page 117.

The proposed Diesel-fuel-oil classification was approved by letter ballot of the committee for publication as information and appears in the Appendix on page 440.

Recommendation to Committee E-10 on Standards.—Subsequent to the annual meeting proposed Tentative Specifications for Fuel Oils were presented to the Society through Committee E-10 on Standards. The proposed specifications were accepted on August 22, 1934, for publication as tentative by Committee E-10 and appear on page 882.

REPORT OF TECHNICAL COMMITTEE A ON GASOLINE

Technical Committee A on Gasoline has held two meetings during the past year, at Detroit, Mich., in January, and at Washington, D. C., in March.

Section V on Specifications, C. B. Veal, chairman, was created in January as a result of frequent requests to the Society for help in preparing gasoline specifications. The organization of this new section was reported to and accepted by Technical Committee A in March as follows:

Objective.—To determine the significance of the specification items for gasoline with reference to its performance in automotive engines (other than aircraft engines) and to indicate the economic factors involved in the formation of specifications.

Purpose of Information.—To serve as a guide in (*a*) formulation of specifications (for consumers primarily); (*b*) design of automotive engines, and (*c*) manufacture of gasoline.

Problems.—Determination of the extent to which the specification characteristics of gasoline affect (*a*) engine performance; (*b*) engine maintenance; (*c*) gasoline stability in storage as well as in use, and (*d*) gasoline cost to the consumer.

Plan.—Because progressive changes in engines and fuels impose a temporary significance on reports from this section, yearly revisions are to be expected. It is hoped that the section can publish its initial report in June, 1935.

Section I on Gum (T. H. Rogers, chairman):

There are three distinct problems involved in the work on gum formation in gasoline: gum tolerance, gum content, and gum stability. The work previously reported has served to establish approximately the permissible gum content of gasoline in service. Various considerations indicated that a more exact experimental treatment of this subject was not justified at this time, in view of the need for standard methods for determining gum content and gum stability.

Gum Content.—Each of Methods A and B, described in the previous report,[1] has been studied intensively in a series of cooperative tests. The major problem has been to attain the desired concordance in results between different laboratories, as it has been common experience that reproducibility by a single operator is very satisfactory. Apparently this lack of agreement is due to the complex reactions taking place during the evaporation of gasoline that has been oxidized. The actual quantity of non-volatile residue varies widely with the conditions of evaporation and subsequent heating, particularly with the conditions obtaining just after the volatile gasoline has been driven off. For this reason slight differences in technique—even with the procedure carefully specified—causes variations, particularly in Method A where the residue is heated at a different temperature than that at which evaporation takes place.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 407 (1932).

In an effort to eliminate sources of error modifications of each of the methods were tried. The use of a beaker instead of the dish in Method A gave some improvement, but not that desired; results were still somewhat more encouraging by Method B and the simplicity and greater speed of the latter method were in its favor. Next a series of tests was carried out, in which the temperature employed in Method B was varied. These results showed that the gum content decreased with rising temperature, the values flattening out at temperatures of 150 C. and above. The results at 150 to 160 C. were more concordant as will be seen by the following tabulation:

	Method A	Method B at			
		95 C.	123 C.	157 C.	185 C.
Sample J, Gum Content, mg. per 100 ml.					
Average, all laboratories	13.6	23.1	10.7	9.8	8.6
Average deviation, mg	2.4	6.9	2.8	1.7	1.4
Sample K, Gum Content, mg. per 100 ml.					
Average, all laboratories	24.7	37.7	19.5	17.7	18.1
Average deviation, mg	4.1	9.4	3.2	2.9	3.6

It was, therefore, decided that a temperature of approximately 155 C. is most suitable and Method B, with this modification, was presented to the Society and issued in January, 1934, as the Tentative Method of Test for Determining Gum Content of Gasoline (D 381 – 34 T).[1] Table I shows the results obtained by this tentative method in comparison with those obtained by Method A.

It is to be noted that Method D 381 – 34 T gives results which are about two-thirds of those obtained by Method A, this ratio varying somewhat with different gasolines and with different gum contents. In the work on gum tolerance, Method A was employed; hence in terms of Method D 381 - 34 T a correspondingly lower value for gum content should be associated with the performance data[1] obtained.

---

[1] See p. 899.

Gum Stability.—Active work on gum stability was recently started. A consideration of the various accelerated oxidation tests in use in the industry showed that the apparatus and procedure differ markedly. The temperature is the same (100 C.) in all tests and the pressure generally employed is 100 lb. However, the size of bomb, ratio of oxygen to gasoline, criterion of break and correction for temperature lag vary appreciably. A series of tests has been run in which a number of samples of gasolines were interchanged and results obtained by the methods in vogue in the different laboratories. Comparative data by seven different test methods were obtained. In general, though not always, the gasolines were rated in the same order of stability by the different methods though the numerical results differed appreciably. Some data were also obtained by the copper dish test, which did not correlate with the oxidation tests.

TABLE I.—RESULTS OF COOPERATIVE TESTS ON SAMPLE L, GUM CONTENT, MG. PER 100 ML.

Laboratory	Method A					Tentative Method D 381 - 34 T				
	Individual Results			Average	Deviation from Grand Average	Individual Results			Average	Deviation from Grand Average
No. 1	18.8	23.0	19.6	20.5	5.0	7.4	7.2	7.8	7.5	1.1
No. 2	13.8	13.2	14.0	13.7	1.8	9.8	9.4	9.4	9.5	0.9
No. 3	18.0	21.6	20.4	20.0	4.5	10.4	8.2	8.8	9.1	0.5
No. 4	14.4	13.6	14.0	14.0	1.5	9.2	8.0	8.6	8.6	0.0
No. 5	13.6	13.6	13.6	13.6	1.9	8.4	8.6	8.2	8.4	0.2
No. 6	12.6	12.8	13.0	13.0	2.5	8.0	8.0	11.4	9.4	0.8
No. 7	11.4	12.0	11.2	11.5	4.0	5.4	6.0	6.2	5.9	2.7
No. 8	23.2	22.0	22.0	22.4	6.9	8.8	10.0	9.6	9.5	0.9
No. 9	14.6	13.8	14.2	14.2	1.3	11.0	10.8	11.6	11.1	2.5
No. 10	14.0	13.8	13.4	13.7	1.8	7.6	7.4	7.6	7.5	1.1
No. 11	13.0	14.4	13.7	13.7	1.8	8.4	8.0	8.6	8.3	0.3
Grand Average	......	......	......	15.5	3.0				8.6	1.0

These comparisons serve to bring out the relative advantages and disadvantages of the oxidation tests now available. Based on this background the section is now engaged in developing an improved design, including metal bomb, gage and bath. An important objective is the elimination of the lag which is due to the use of a bottle inside the bomb.

The development of a uniform bomb test apparatus is a necessary step toward the study of the significance of oxidation test as regards storage. In this work consideration will also be given to the glass bomb (Voorhees) test with which an extensive amount of correlation work has been done.[1] Another part of the program includes a consideration of the copper-dish test, which, in spite of definite drawbacks, is used to considerable extent in evaluating stability. For this purpose the procedure, as standardized by the Atlantic Refining Laboratory, has been circulated among the members of the section.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 407 (1932).

Section III on Vapor Lock (G. G. Brown, chairman):

Section III on Vapor Lock, in January, 1934, recommended to Technical Committee A that Reid vapor pressure (A.S.T.M. Tentative Method D 323 - 32 T)[2] of fuels as delivered to the fuel tank of the vehicle be established as the criterion of vapor lock quality and that certain specification limits be established. Because of disagreement within the section, Technical Committee A did not act on the recommendation pending further discussion. The following papers[3] on the subject of vapor lock are to be presented at the June, 1934, annual meeting of the Society: "Motor Fuels and Vapor Lock," by G. G. Brown, and "Motors and Fuel Vapor Pressure," by T. A. Boyd.

Section IV on Detonation (T. G. Delbridge, chairman):

Collaborating with the Cooperative Fuel Research Committee (S.A.E., A.P.I. and N.A.C.C.), Section IV on Detonation has recommended a revision[4] of the Tentative Method of Test for Knock Characteristics of Motor Fuels (D 357 - 33 T)[5] to simplify and improve control.

The reproducibility of this method has been checked several times. A paper[6] has been published covering a major series of tests. In general, for all laboratories participating, the average deviation from the mean is 0.7 Octane Number. Improper engine conditions have been the major cause for greater deviations.

An extensive series of cooperative road tests will be carried out in July and August, 1934, under the auspices of the Cooperative Fuel Research Committee to determine whether or not octane numbers determined in the laboratory in accordance with the Tentative Method D 357 - 33 T are still in accord with road results on current engines.

At the request of the Cooperative Fuel Research Committee, Technical Committee A has under consideration the formulation of a method for determining acid heat as applied to aviation gasoline and consideration of the extension of this test for possible application in the testing of other grades of gasoline.

---

[1] T. H. Rogers, J. L. Bussies and P. T. Ward, "Measurement of Gum Stability of Gasoline," *Industrial and Engineering Chemistry*, Vol. 25, p. 397 (1933).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 765 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 569.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part II, pp. 550 and 540, respectively (1934).

[4] See p. 429.—ED.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 746 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 540.

[6] H. F. Huf, "Major Laboratories Report on Reproducibility of Tentative Method of Anti-Knock Testing," *Oil and Gas Journal*, February 22, 1934, p. 20.

Respectfully submitted on behalf of the technical committee,

H. L. HORNING,
Chairman.

T. G. DELBRIDGE,
Secretary.

C. B. VEAL,
Vice-Chairman.

APPENDIX

DIESEL-FUEL-OIL CLASSIFICATION

Manufacturers and users of Diesel engines, as well as petroleum refiners and distributors, have long felt the need for some classification differentiating types of fuel oils suitable for Diesel-type engines. The classification shown in Table I, covering five grades of oil, was developed by Technical Committee C on Fuel Oils (Including Diesel Fuel) of Committee D-2 on Petroleum Products and Lubricants in an

TABLE I.—DIESEL-FUEL-OIL CLASSIFICATION.

Grade of Diesel Fue	Flash Point, deg. Fahr	Water and Sediment, per cent by volume	Viscosity, seconds			Carbon Residue, per cent by weight	Ash, per cent by weight	Pour Point, deg. Fahr.	Sulfur	Ignition Quality
			Saybolt Universal (at 100 F.)		Saybolt Furol (at 122 F.)					
	Min.[f]	Max.	Min.	Max.	Max.	Max.	Max.	Max.[h]		
No. 1-D[a] A distillate oil for use in engines requiring a low-viscosity fuel....	115 or legal	0.05	32	50	...	0.2	0.01	35	[i]	[j]
No. 3-D[b] A distillate oil for use in engines requiring a medium-low-viscosity fuel................	150	0.2	32	70	...	0.5	0.02	35	[i]	[j]
No. 4-D[c] An oil for use in engines requiring a medium - low - viscosity fuel................	150	0.6	..	500	...	3.0	0.04	35	[i]	[j]
No. 5-D[d] An oil for use in engines permitting a medium-high-viscosity fuel............	150	[g]	..	...	100	6.0	0.08	40	[i]	
No. 6-D[e] An oil for use in engines of special design for high-viscosity fuels and after engine manufacturers' recommendations only..	150	[g]	..	...	300	10.0	0.12	40	[i]	[j]

[a] Grade No. 1-D is recommended for mechanical (solid)-injection engines of the high-speed type; in general, for engine speeds over 1000 r.p.m.

[b] Grade No. 3-D is recommended for mechanical (solid)-injection engines of the medium-speed type; in general, for engine speeds from 360 to 1000 r.p.m.

[c] Grade No. 4-D is recommended for air-injection engines, both two- and four-stroke cycle types, with speeds not over 400 r.p.m. Grade No. 4-D can be used for mechanical (solid)-injection engines with cylinder diameters over 16 in. and speed under 240 r.p.m., but approved heating equipment furnished by the engine manufacturer is recommended.

[d] Grade No. 5-D is recommended for air-injection engines of the slow-speed type; speed under 240 r.p.m. Manufacturer should be consulted for approved heating equipment.

[e] Grade No. 6-D is not regularly used for Diesel engines and is not recommended unless tested and approved by engine manufacturer. The purchaser should be informed regarding high maintenance cost of engines and operating problems involved in the use of this grade of fuel.

[f] Minimum flash point as stated or as required by local fire regulations, Fire Underwriters or state laws.

[g] To be inserted later.

[h] Lower pour points may be specified whenever required by local temperature conditions to facilitate storage and use, although it should not be necessary to specify a pour point of less than 0 F.

[i] So far as known, sulfur content need not be considered as regards combustion characteristics. However, a maximum of 2 per cent is suggested to purchasers operating engines in intermittent service, to limit corrosion.

[j] See discussion under Methods of Testing, Paragraph (*g*) Ignition Quality.

attempt to supply this need. It is not the intention of the committee that this classification should be used as purchase specifications; but rather that fuels purchased be correlated according to the proposed classification in order to determine its usefulness. A series of Diesel-fuel-oil specifications should evolve as a result of this program. Criticism and comment should be forwarded to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 50 West 50th St., New York City.

METHODS OF TESTING

The properties listed in this classification are determined in accordance with the following methods of testing:

(*a*) *Flash Point.*—In absence of legal or local requirements, the minimum flash point shall be determined in accordance with the Standard Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (A.S.T.M. Designation: D 93) of the American Society for Testing Materials.[1]

(*b*) *Viscosity.*—Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (A.S.T.M. Designation: D 88) of the American Society for Testing Materials.[2]

(*c*) *Carbon Residue.*—Standard Method of Test for Carbon Residue of Petroleum Products (Conradson Carbon Residue) (A.S.T.M. Designation: D 189) of the American Society for Testing Materials.[3]

(*d*) *Ash.*—Place 10 g. of the fuel oil in a weighed uncovered platinum crucible of a capacity not greater than 100 ml. and heat gently with a Bunsen burner until the oil fires and continues to burn when the flame of the burner is applied to the surface of the oil. Allow the oil to burn without further application of heat. The oil will continue to burn until practically all of it has disappeared. The time required will be about 50 min. Then place the platinum crucible in a gas or electric furnace and heat to a bright red heat until all carbon is consumed. Cool, weigh and report the residue as ash expressed as a percentage of the original 10-g. sample.

(*e*) *Pour Point.*—Standard Method of Test for Cloud and Pour Points (A.S.T.M. Designation: D 97) of the American Society for Testing Materials.[4]

(*f*) *Sulfur.*—Standard Method of Test for Sulfur in Petroleum Oils by Bomb Method (A.S.T.M. Designation: D 129) of the American Society for Testing Materials.[5]

(*g*) *Ignition Quality.*—According to present opinion, combustion knock in a fuel-oil-injection engine is caused by the accumulation of fuel in its cylinders prior to ignition. Even under conditions that insure ignition, the fuel may not ignite instantaneously but only after a definite delay. The longer this delay, the more fuel accumulates in the cylinders, which then burns unevenly, finally causing audible knock. If the delay is extreme, the engine will fail to operate with the fuel. It is significant that every factor which tends to aggravate knocking in a spark-ignition gasoline engine tends to suppress it in Diesel engines. Fuels of paraffin base consisting chiefly of saturated straight-chain hydrocarbons give the smoothest combustion in general, while naphthenes and aromatics burn roughly at low compression ratios. It is known that highly cracked products give trouble and also that the amount of trouble is increased as the speed of the engine is increased. Turbulence in the charge mixture reduces the delay period and turbulence is a controlling factor in engine speed. It is now generally agreed that ignition quality is one of the most important characteristics of Diesel fuels.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 805.

[2] *Ibid.*, p. 880.

[3] *Ibid.*, p. 757.

[4] 1934 Supplement to Book of A.S.T.M. Standards, p. 117.

[5] *Ibid.*, p. 124.

The committee realizes the impossibility of reducing all types and designs of engines to a common rating for fuel-burning characteristics. Engine factors, such as combustion-chamber design, turbulence, spray characteristics, compression ratio, injection timing, and engine speed, vary greatly in different engine makes. Tests of ignitibility on various types of engines have no theoretical significance but have provided practical data for the types and sizes of engines on which the tests were performed. Fuel characteristics are based on a study of field-engine performance correlated with laboratory ratings of various test fuels. Ignitibility, one of the most important characteristics from the standpoint of satisfactory engine operation, has been measured by such indices of performance as Diesel index number, cetene number and critical compression ratio.

DIESEL INDEX NUMBER.—Diesel index number is calculated from aniline point and A.P.I. gravity by the following formula:

$$\text{Diesel Index Number} = \frac{(\text{A.P.I. gravity at 60 F.}) \times (\text{aniline point in deg. Fahr.})}{100}$$

Aniline Point is the lowest temperature at which equal parts of volume of freshly distilled aniline and the test sample of oil are completely miscible. It is determined by heating such a mixture in a jacketed test tube to a clear solution and noting the temperature at which turbidity appears as the mixture is cooled.

For A.P.I. Gravity see the Standard Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (A.S.T.M. Designation: D 287) of the American Society for Testing Materials.[1]

CETENE NUMBER.—Cetene Number was first proposed by Boerlage and Broeze of the Bataafsche Petroleum Maatschappij[2] and is the percentage of cetene in a blend of cetene and alphamethylnaphthalene which has the same ignition quality (measured in a specified engine under a definite set of engine conditions) as the fuel under test. It may be determined from the critical compression ratio by determining this ratio for various blends of cetene and alphamethylnaphthalene and plotting the curve.

CRITICAL COMPRESSION RATIO.—The critical compression was first proposed by Pope and Murdock of the Waukesha Motor Co.[3] It is determined on a C.F.R. engine modified to run as a Diesel engine by replacing the ignition system with a fuel pump and fuel injection valve and also replacing the regular piston with one of special design. The operating conditions are as follows:

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 819.

[2] Boerlage and Broeze, "Ignition Quality of Diesel Fuels as Expressed in Cetene Numbers," *Journal*, Soc. Automotive Engrs., July, 1932.

[3] Pope and Murdock, "Compression Ignition Characteristics of Diesel Fuels," *Journal*, Soc. Automotive Engrs., March, 1932.

Speed	600 r.p.m.
Fuel feed	9 ml. per min.
Injection advance angle	12 deg. before true dead center
Injection pressure	1500 lb. per sq. in.
Jacket temperature	212 F.
Air inlet temperature	100 F.

The critical compression ratio is obtained by motoring the engine at the selected speed and noting the compression ratio at which firing occurs (as judged by the sound of the exhaust) within 3 sec. after the fuel is injected.

None of these methods has been sufficiently correlated with service performance to justify setting definite limits. Field investigators are urged in reporting results to state whether the following limits, if set, would be satisfactory for Diesel oils, Grades Nos. 1-D, 3-D and 4-D:

	OIL GRADES		
	No. 1-D	No. 3-D	No. 4-D
Diesel Index Number, min	45	30	20
Cetene Number, min	50	40	30
Critical Compression Ratio, max	8.1	8.8	9.8

These methods are not considered practicable for determining the ignition quality of Diesel oils, Grades Nos. 5-D and 6-D. It is doubtful whether any test other than an actual engine test would be satisfactory for these heavy oils.

REPORT OF COMMITTEE D-4
ON
ROAD AND PAVING MATERIALS

Committee D-4 on Road and Paving Materials has only two recommendations to make to the Society at the 1934 annual meeting but it believes that shortly thereafter it will be in a position to present, through Committee E-10 on Standards, a number of new tentative specifications and methods of tests. These new proposed specifications and tests are therefore appended hereto for general information in connection with the reports from the several subcommittees in which they originated: namely, Subcommittees B-3 on Distillation, B-17 on Emulsion Tests and C-4 on Emulsified Asphalts.

Committee D-4 wishes to direct attention to the progress report of Subcommittee X on Standard Coefficient of Expansion for Bituminous Products, appended to the annual report of Committee D-8 on Bituminous Waterproofing and Roofing Materials, as this subcommittee is identical with its own Subcommittee B-8 on Coefficient of Expansion of Bituminous Materials.

During the past year Committee D-4 cooperated with Committee D-2 on Petroleum Products and Lubricants in the preparation of that portion of a revised report on the Significance of Tests of Petroleum Products which is of mutual interest to the two committees. The second edition of the report will soon be published.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee B-3 on Distillation (W. H. Fulweiler, chairman).—This subcommittee has had under development for some years a method for the distillation of cut-back asphalts. In its report appended hereto the subcommittee records the results of a cooperative series of tests carried on during 1933 and presents as information a proposed method of test for distillation of liquid asphaltic products which the committee is planning to present to the Society through Committee E-10 on Standards after the annual meeting.[1]

Subcommittee B-17 on Emulsion Tests (J. S. Miller, Jr., chairman).—During the past year this subcommittee, in cooperation with Subcommittee C-4 on Emulsified Asphalts, has developed an extensive revision of the existing Tentative Methods of Testing Bituminous Emulsions (D 244 - 33 T). The proposed revised methods, which are appended hereto[1] as information, comprise tests for viscosity, distillation, settlement, demulsibility, sieve test, freezing test, coating test, penetration of residue, solubility of residue, ductility of residue, specific gravity of residue and ash in residue. The revised methods will be submitted to the Society through Committee E-10 subsequent to the annual meeting.[2]

---

[1] See Editorial Note, p. 446.—Ed.

Subcommittee C-4 on Emulsified Asphalts (J. E. Myers, chairman).—This subcommittee in cooperation with Subcommittee B-17 on Emulsion Tests has prepared five new proposed tentative specifications for emulsified asphalts as follows:

Tentative Specifications for:
- Emulsified Asphalt (Coarse Aggregate Plant Mixes)
- Emulsified Asphalt (Retread and Coarse Aggregate Mixes)
- Emulsified Asphalt (Heavy Premix—Winter Grade)
- Emulsified Asphalt (Heavy Premix—Summer Grade)
- Emulsified Asphalt (Quick Setting) for Penetration and Surface Treatment

These specifications, which are appended hereto[3] as information, will be submitted to the Society through Committee E-10 subsequent to the annual meeting.[2]

RECOMMENDATIONS AFFECTING STANDARDS

The committee recommends that the Tentative Specifications for Calcium Chloride (D 98 - 33 T),[4] with the following minor revision, be approved for submission to letter ballot of the Society for adoption as standard:

Section 3.—Change the third requirement under chemical composition to read as follows by the addition of the italicized words and the omission of those in brackets:

[NaCl] *Total alkali chlorides*....................not more than 2.0 per cent

This proposed revision coincides with customary requirements and brings these specifications into closer conformity with the Tentative Methods of Chemical Analysis of Calcium Chloride (D 345 - 32 T).

---

[1] See p. 926.—ED.

[2] See Editorial Note, p. 446.—ED.

[3] See pp. 916 to 925.—ED.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 762 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 604.

No criticisms having been received during the past year of the Tentative Methods of Chemical Analysis of Calcium Chloride (D 345 – 32 T),[1] the committee also recommends that they be approved for submission to letter ballot of the Society for adoption as standard.

In connection with its tentative standards which have been published for three or more years without revision, Committee D-4 regrets that it is unable at this time to recommend their adoption as standard. It hopes, however, to include definite recommendations regarding them in its next annual report.

The election of officers for the ensuing term of two years resulted in the selection of M. H. Ulman, chairman; R. L. Morrison, A. T. Goldbeck, C. S. Reeve, vice-chairmen; and Prévost Hubbard, secretary.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 92 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Tentative Specifications for Calcium Chloride (D 98 – 33 T), as revised	48	1	43
Tentative Methods of Chemical Analysis of Calcium Chloride (D 345 – 32 T)	49	1	42

This report has been submitted to letter ballot of the committee, which consists of 92 members; 65 members returned their ballots, of whom 59 have voted affirmatively and 2 negatively.

Respectfully submitted on behalf of the committee,

H. F. CLEMMER,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Calcium Chloride, as revised, and Methods of Chemical Analysis of Calcium Chloride were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 138 and 140, respectively.

Recommendations to Committee E-10 on Standards.—Subsequent to the annual meeting Committee D-4 on Road and Paving Materials presented to the Society through Committee E-10 on Standards, the following additional recommendations referred to in the report which were accepted by Committee E-10 on August 22, 1934:

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 777 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 637.

Proposed Tentative Specifications for Emulsified Asphalt (for Coarse Aggregate Plant Mixes), for Emulsified Asphalt (for Retread and Coarse Aggregate Mixes), for Emulsified Asphalt (Heavy Premix—Summer Grade), for Emulsified Asphalt (Heavy Premix—Winter Grade), and for Emulsified Asphalt ((Quick-Setting) for Penetration and Surface Treatment) were accepted and appear on pages 916 to 925.

A proposed Tentative Method of Test for Separation of Liquid Asphaltic Products was accepted and appears on page 938.

Revisions of the Tentative Methods of Testing Bituminous Emulsions, which revised methods have been combined with other tests for bituminous emulsions prepared by Committee D-8 on Bituminous Waterproofing and Roofing Materials under the title "Tentative Methods of Testing Emulsified Asphalts," were accepted. The combined methods appear on page 926.

REPORT OF SUBCOMMITTEE B-3 ON DISTILLATION

The Distillation Section under the old set-up of Committee D-4 and later Subcommittee B-3 has been working since 1926 on the development of a method for the separation of the base and flux of asphaltic cut-back products. A very large amount of cooperative work has been done on this subject. The progress of the work was summarized in the report of the special committee published as an appendix to the 1930 report of Committee D-4.[1]

It will be noted that various modifications of the distillation procedure have been tried out, including vacuum distillation and the use of a steam distillation following the usual fire distillation. In the past there has been no particular difficulty in securing a fair approximation of the character and amount of the flux but the character of the recovered base has been influenced by the character of the flux used.

TABLE I.—MODIFICATIONS OF STANDARD DISTILLATION METHOD USED IN THE DIFFERENT TESTS.

Test	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
Size of sample, ml.	200	200	100	100	200	200	200	200	200	200	200	200
Position of thermometer bulb from bottom of flask, in.[a]	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$
Length of water jacket, cm.	250	250	250	250	250	250	250	250	250	250	300	300
Size of can for residue, oz.[b]	8	6	8	6	8	6	8	6	8	6	8	6

[a] $\frac{1}{4}$ in. = 6.3 mm.; $\frac{1}{2}$ in. = 12.7 mm.

[b] 6 oz. = 177.5 ml.; 8 oz. = 236.5 ml.

Subsequent to 1930, a rather elaborate cooperative investigation was undertaken by the American Association of State Highway Officials. This investigation indicated that the modification of the Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 – 30)[2] would probably be found satisfactory, certain points, however, were still unsettled. These had to do with the size of the sample, the exact position of the thermometer bulb, length of the condenser jacket and the size of the can used for receiving the residue. These points were covered in a cooperative investigation carried on during 1933, the results of which are shown in Tables I, II and III.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 801 (1930).

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 953.

TABLE II.—RESULTS OF DISTILLATION TESTS IN PERCENTAGE BY VOLUME OF WATER-FREE MATERIAL.

Material	Medium Curing				Slow Curing				Rapid Curing			
Test	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
TOTAL DISTILLATE TO 437 F. (225 C.)												
Laboratory A	trace	trace	0	0	0	0	0	0	27.0	27.0	26.5	27.0
Laboratory B	trace	trace	0	0	0.5	0.5	0.5	0.5	27.0	27.0	27.5	27.0
Laboratory C	0.5	0.5	0	0	1.0	0.5	0.7	0.7	27.5	27.2	27.2	27.2
Laboratory D[a]	1.0	0.5	....	....	trace	trace	....	....	....	....	27.5	27.0
Laboratory E	trace	trace	trace	trace	trace	trace	trace	trace	27.5	27.5	27.0	27.0
Average	0.3	0.2	0	0	0.3	0.2	0.3	0.3	27.3	27.2	27.1	27.0
Maximum deviation	+0.7	+0.3	trace	trace	+0.7	+0.3	+0.4	+0.4	−0.5	+0.3	−0.6	+0.2
TOTAL DISTILLATE TO 600 F. (315 C.)												
Laboratory A	17.0	17.0	16.0	16.0	17.5	17.0	17.5	17.5	32.0	32.0	31.5	31.5
Laboratory B	17.0	17.5	16.5	16.0	18.0	17.0	17.5	17.5	32.0	32.0	32.0	32.0
Laboratory C	17.5	17.5	16.3	17.0	18.0	18.0	18.0	18.0	32.0	31.5	31.5	32.0
Laboratory D[a]	16.0	15.5	....	....	19.0	18.0	....	....	....	....	32.5	32.5
Laboratory E	17.5	17.5	17.0	17.0	17.5	17.5	17.5	17.5	32.0	32.0	32.0	32.0
Average	17.0	17.0	16.3	16.5	17.8	17.5	17.6	17.6	32.0	31.9	31.9	32.0
Maximum deviation	−1.0	−1.5	+0.7	±0.5	+1.2	±0.5	+0.4	+0.4	±0.0	−0.4	+0.6	±0.5
TOTAL DISTILLATE TO 680 F. (360 C.)												
Laboratory A	21.5	22.0	22.0	22.0	26.0	25.5	26.0	26.0	33.5	34.0	33.5	33.5
Laboratory B	21.8	21.8	21.5	21.5	26.3	25.5	26.0	26.0	33.0	33.5	33.5	33.5
Laboratory C	22.0	22.0	22.0	22.0	26.5	26.5	26.3	26.5	33.8	33.5	33.5	33.5
Laboratory D[a]	20.5	21.0	....	....	26.0	26.5	....	....	....	....	34.0	34.5
Laboratory E	22.0	22.0	22.0	21.0	27.0	27.0	27.0	27.0	34.0	34.0	34.0	34.0
Average	21.6	21.8	21.9	21.6	26.4	26.2	26.3	26.4	33.8	33.8	33.7	33.8
Maximum deviation	−1.1	−0.8	−0.4	±0.4	+0.6	+0.8	+0.7	+0.6	−0.8	−0.3	+0.3	+0.7

[a] Laboratory D did not make tests Nos. 3, 4, 7, 8, 9 and 10.

TABLE III.—CHARACTERISTICS OF RESIDUE FROM DISTILLATION.[a]

Material	Medium Curing				Slow Curing				Rapid Curing			
Test	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
	Penetration at 25 C. (77 F.), 100 g., 5 seconds				Float Test at 78 C. (172 F.), seconds				Penetration at 25 C. (77 F.), 100 g., 5 seconds			
Laboratory A[b]	157	143	138	150	52	53	57	53	60	61	62	62
Laboratory B[c]	157	147	124	131	0	0	0	0	60	61	62	64
Laboratory C[d]	148	146	154	148	65	64	71	68	64	62	67	66
Laboratory D[e]	152	165	...	...	72	57	..	..	..	..	70	82
Laboratory E[f]	147	150	150	148	0	0	0	0	62	62	64	62
Average	152	150	141	144	61.5	58.0	64.0	60.5	61.5	61.5	65.0	67.0
Maximum deviation	−5	+15	+13	−13	+10.5	+6	+7	±7.5	+2.5	±5	+5	+15

[a] All laboratories reported the ductility of residue as 100 + cm.

[b] Laboratory A reported considerable difficulty from foaming in tests Nos. 5, 6, 7, 8, 9, 10, 11 and 12.

[c] Laboratory B reported that tests Nos. 1 and 2 foamed slightly; that in tests Nos. 5, 6, 7 and 8 foaming retarded distillation at start; and tests Nos. 9, 10, 11 and 12 foamed at 446 to 617 F. (230 to 325 C.).

[d] Laboratory C reported that foaming observed in tests Nos. 5, 6, 7 and 8 slowed up rate of distillation.

[e] Laboratory D reported no trouble in any of the tests from foaming. Did not make tests Nos. 3, 4, 7, 8, 9 and 10.

[f] Laboratory E reported that foaming was observed in tests Nos. 3 and 4.

Results from the following cooperating laboratories are reported

Laboratory A. Mr. A. W. Dow, Chemical and Paving Engineer.
Laboratory B. New Jersey State Highway Department, Mr. R. B. Gage.
Laboratory C. The Asphalt Institute, Mr. Prévost Hubbard.
Laboratory D. New York State Highway Commission, Mr. J. E. Myers.
Laboratory E. Pennsylvania State Highway Department, Mr. M. H. Ulman.

In view of satisfactory results obtained, the subcommittee is recommending for consideration the Proposed Method of Test for Separation of Liquid Asphaltic Products, appended hereto.[1] The method will be submitted to the Society for publication as tentative through Committee E-10 on Standards subsequent to the annual meeting.[2]

Respectfully submitted on behalf of the subcommittee,

W. H. FULWEILER,
Chairman.

---

[1] See p. 938.—ED.

[2] See Editorial Note, p. 446.—ED.

REPORT OF COMMITTEE D-5
ON
COAL AND COKE

Committee D-5 on Coal and Coke held three meetings during the year, one each in Chicago, Ill., on June 29, 1933, in Washington, D. C., on March 6, 1934, and in Atlantic City, N. J., on June 26. The Tentative Method of Sampling Coke for Analysis (D 346 – 33 T) is being continued as tentative pending possible modification. The Tentative Definition of the Term Coke (D 121 – 30 T) is being referred back to Committee E-8 on Nomenclature and Definitions for reconsideration. The tentative revision of the Standard Method of Test for Size of Anthracite (D 310 – 31), modified as indicated later, is also being recommended for adoption as standard. The committee is recommending for publication as information a new method of test for agglutinating value of coal.

Activities of Subcommittees

Subcommittee I on Methods of Testing (W. A. Selvig, chairman).—Experimental work by this subcommittee is in progress with a view to standardizing a method of test for measuring the slacking or weathering properties of coals. The test under consideration is that developed at the Pittsburgh station of the U. S. Bureau of Mines.[1] This test consists in air-drying 500 to 1000 g. of approximately 1 to 1½ in. lumps of coal at a temperature of 30 to 35 C. for a period of 24 hr., and then immersing the lumps in water for 1 hr., the water then being drained off, and the sample again air-dried for 24 hr. The amount of disintegration of the coal lumps is determined by sieving on an 8-in. wire-mesh sieve with 0.263-in. square openings. It has been found that the humidity of the atmosphere in the oven used for air-drying is important, especially in the case of highly slacking coals, so experiments are being made with a view to determining the most suitable humidity for the air-drying process. Preliminary tests indicate that a relative humidity of 30 to 35 per cent will be suitable.

Subcommittee II on Nomenclature and Definitions (H. C. Porter, chairman).—In cooperation with the Subcommittee on Definition of the Term Coke of Committee E-8 on Nomenclature and Definitions, a revision of the Tentative Definition of the Term Coke (D 121 –

---

[1] A. C. Fieldner, W. A. Selvig and W. H. Frederic, "Accelerated Laboratory Test for Determination of Slacking Characteristics of Coal," U. S. Bureau of Mines *Report of Investigations No. 3055* (1930).

30 T) was prepared. This revised definition[1] was subsequently approved by Committeee E-8 and also approved by Committee D-5 at the March 6, 1934, meeting. Since publication of this definition and approval by letter ballot of Committee D-5, it developed that this definition is not satisfactory to Committee D-2 on Petroleum Products and Lubricants. Accordingly, at a meeting of Committee D-5 held on June 26, it was voted to refer this definition back to Committee E-8 for reconsideration before recommending it to the Society for adoption as standard.

The subcommittee, in cooperation with the Subcommittee on Definitions of Net and Gross Calorific Values of Committee E-8 on Nomenclature and Definitions, prepared the following definitions of gross calorific value and of net calorific value, which definitions have been submitted to Committee E-8 for approval:

Gross Calorific Value, H_s.—In the case of solid fuels and liquid fuels of low volatility, the heat produced by combustion of unit quantity, at constant volume, in an oxygen bomb calorimeter under specified conditions.

Note.—The conditions are: initial oxygen pressure of 20 to 40 atmospheres, final temperature of 68 to 95 F. (20 to 35 C.), products in form of ash, liquid water, and gaseous CO_2, SO_2 and nitrogen. This definition is not applied to gaseous or highly volatile liquid fuels.

Net Calorific Value, H_i.—In the case of solid fuels and liquid fuels of low volatility, a lower value calculated from the gross calorific value as the heat produced by combustion of unit quantity, at constant atmospheric pressure, under conditions such that all water in the products remains in the form of vapor.

Note.—The net calorific value is calculated from the gross calorific value by making a deduction of 1020 B.t.u. per lb. (567 cal. per g.) of water derived from unit quantity of fuel, including both the water originally present as moisture and that formed by combustion. The deduction is not equal to the latent heat of vaporization of water (1050 B.t.u. per pound at 75 F., 24 C.) because the calculation is made to reduce from gross value at constant volume to net value at constant pressure, for which the correct factor is 1020 B.t.u. per lb.

At the meeting of Committee D-5 held on June 26, it was voted to recommend these definitions as tentative subject to the usual letter ballot vote of Committee D-5.

Subcommittee VII on Pulverizing Characteristics of Coal (John Van Brunt, chairman).—This subcommittee held a meeting in New York City on February 21, 1934. A method of laboratory testing of grindability of coal has been developed at the Seattle station of the U. S. Bureau of Mines. This is a ball-mill method and is described in a paper by H. F. Yancey, O. L. Furse and R. A. Blackburn, entitled, "Estimation of the Grindability of Coal," presented at a meeting of the Coal Division, American Institute of Mining and Metallurgical Engineers at New York City, February 20, 1934.

---

[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 33, Part I, p. 499 (1933).

A paper describing a ball-mill method developed at the Fuel Research Laboratories, Department of Mines, Ottawa, Canada, was published during the year under the title "A Method for Rating the Grindability or Pulverizability of Coal, Developed by the Fuel Research Laboratories, Department of Mines, Canada,"[1] by C. E. Baltzer and H. P. Hudson.

The committee during the coming year will make cooperative grindability tests by various proposed laboratory methods, on a number of coals varying in hardness, with a view to establishing the most suitable laboratory method of test.

Subcommittee XI on Coal Friability (R. E. Gilmore, chairman).—This subcommittee held a meeting in New York City on February 21, 1934. Active work on the comparison of different methods for testing the friability of coal has been continued during the year. Experimental work done at the Seattle station of the U. S. Bureau of Mines has been published.[2] At the Fuel Research Laboratories of the Department of Mines, Canada, considerable experimental work has been conducted on a series of seven coals varying widely in friability. In these tests six different methods were used, including both tumbler and shatter methods. The results of these experiments will be published soon by the Canada Department of Mines.

Subcommittee XII on Sampling Coal at Coal Cleaning Plants (T. W. Guy, chairman).—This subcommittee has been active during the past year collecting and evaluating data on sampling methods applicable to coal cleaning plants. A large number of sampling experiments have been made of float and sink samples with a view to establishing sampling methods for determination of refuse in coal.

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Revision of Existing Standard:

Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (*D 271 – 33*).[3]—Under Calorimetric Determination, Section 40 (*e*) of these methods, there appears the statement that the bomb when filled should contain at least 5 per cent nitrogen, whereas in Section 41 (*c*) a method of filling the bomb with oxygen is given and it is stated that this method should insure 4 per cent of nitrogen in the larger bombs, irrespective of the nitrogen contained in the oxygen. These two statements are contradictory and should be reconciled. The method now universally used in the calorimetri determination for coal and coke is to fill the bomb with oxygen without displacing the original air in the bomb. It is accordingly recommended that the following revision be made and as this propose change is one of form only and does not change the substance o meaning of the method it is considered to be an editorial revision:

---

[1] Advance Section of Investigations of Fuels and Fuel Testing, 1932; *Report No. 737-1*, Mines Branch, Canada Department of Mines, Ottawa, Canada (1933).

[2] H. F. Yancey and R. E. Zane, "Comparison of Methods for Determining the Friability of Coal," U. S. Bureau of Mines *Report of Investigations No. 3215* (1933).

[3] 1933 Book of A.S.T.M. Standards, Part II, p. 269.

Section 40 (e).—Delete the second sentence which reads a follows:

The bomb when filled should contain at least 5 per cent of nitrogen t insure complete oxidation of the sulfur.

Section 41 (c).—Change to read as follows by the addition of th italicized words and the omission of those in brackets:

(*c*) Filling the Bomb with Oxygen.—Oxygen from the supply tank shal be admitted slowly to avoid blowing the sample from the crucible ***without displacing the original air content***, and the pressure allowed to reach 20 atmospheres for the larger bombs or about 30 atmospheres for the smaller bombs, so that the bomb shall contain an amount of oxygen sufficient for complete combustion namely, at least 5 g. per gram of the sample. This method of filling shoul insure [4 per cent of nitrogen in the larger bombs, irrespective of the nitroge contained in the oxygen] ***sufficient nitrogen for complete oxidation of the sulfu in the coal.***[1]

II. Adoption of Tentative Revision of Standard as Standard:

Standard Method of Test for Size of Anthracite (D 310 – 31).[2]— The committee recommends that the tentative revision[3] proposed last year be adopted as standard, except that it be changed to read as follows:

Section 3.—Change this section of the method to read as follows

3. (*a*) The screen openings adopted by the Anthracite Institute, April 1, 1931, as specifications for the preparation of anthracite, are as follows:

SIZE	SIZE OF ROUND-HOLE OPENINGS IN TESTING SCREENS
Broken	Passing a $4\frac{3}{8}$-in. screen, retained on a $3\frac{1}{4}$-in. screen
Egg	Passing a $3\frac{1}{4}$-in. screen, retained on a $2\frac{7}{16}$-in. scree
Stove	Passing a $2\frac{7}{16}$-in. screen, retained on a $1\frac{5}{8}$-in. scree
Chestnut	Passing a $1\frac{5}{8}$-in. screen, retained on a $\frac{13}{16}$-in. screen
Pea	Passing a $\frac{13}{16}$-in. screen, retained on a $\frac{9}{16}$-in. screen
No. 1 Buckwheat	Passing a $\frac{9}{16}$-in. screen, retained on a $\frac{5}{16}$-in. screen
No. 2 Buckwheat (Rice)	Passing a $\frac{5}{16}$-in. screen, retained on a $\frac{3}{16}$-in. screen
No. 3 Buckwheat (Barley)	Passing a $\frac{3}{16}$-in. screen, retained on a $\frac{3}{32}$-in. screen

NOTE.—Tolerances of ± 3 per cent on average openings and of 10 per cent in maximum openings are permissible.

---

[1] S. H. Regester, "Oxidation of Sulfur Compounds of Coal, and of Nitrogen in the Bomb Calorimeter, and the Correction to Be Applied in Determining the Heating Value of Coal," *Industrial and Engineering Chemistry*, Vol. 6, p. 812 (1914).

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 332.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 1049 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 1087.

(b) When testing coal, therefore, to determine conformity with these specifications, these sizes of screen openings shall be used in the test.

III. Publication as Information of Proposed Method:

Proposed Method of Test for Agglutinating Value of Coal.—The committee recommends that this method of test be published as information as appended hereto.[1] This is a small-scale laboratory test intended to give information regarding the coking and caking properties of coal. The method was developed by Subcommittee I on Methods of Testing (W. A. Selvig, chairman), and is based on data given in a paper by W. A. Selvig, B. B. Beattie and J. B. Clelland entitled "Agglutinating-Value Test for Coal" published in the 1933 *Proceedings* of the Society.[2] The proposed method was also approved by Subcommittee VI on Agglutinating Value (W. H. Fulweiler, chairman).

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 39 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF STANDARD			
Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 - 33), editorial revision	39	0	0
II. ADOPTION OF TENTATIVE REVISION OF STANDARD AS STANDARD			
Method of Test for Size of Anthracite (D 310 - 31)	32	0	7
III. PUBLICATION AS INFORMATION OF PROPOSED METHOD			
Method of Test for Agglutinating Value of Coal	30	1	8

This report has been submitted to letter ballot of the committee, which consists of 39 members; 39 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

A. C. FIELDNER,
Chairman.
H. C. PORTER,
Vice-Chairman.

W. A. SELVIG,
Secretary.

---

[1] See p. 457.—ED.

[2] W. A. Selvig, B. B. Beattie and J. B. Clelland, "Agglutinating-Value Test for Coal," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 741 (1933).

EDITORIAL NOTE

The proposed Method of Test for Agglutinating Value of Coal, proposed as tentative in the report as preprinted, was recommended for publication as information on the floor of the annual meeting, see Summary of Proceedings, page 6. This recommendation was accepted and the proposed specifications appear in the Appendix, page 457.

The proposed editorial revision of the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke was accepted.

The recommendation for the adoption as standard of the Tentative Definition of the Term Coke, which appeared in the report as preprinted, was withdrawn at the annual meeting, see Summary of Proceedings, page 6.

The tentative revision of the Standard Method of Test for Size of Anthracite, as modified on the floor of the annual meeting, see Summary of Proceedings, page 7, was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934. The method in its revised form appears in the 1934 Supplement to Book of A.S.T.M. Standards, page 135.

In view of the actions taken with respect to the definition of the term coke and the revision of the test for size of anthracite the minority reports on these subjects which appeared with the report as preprinted have been withdrawn.

APPENDIX

PROPOSED METHOD OF TEST
FOR
AGGLUTINATING VALUE OF COAL[1]

This is a **proposed method** and is published as information only. Suggestions for revision are solicited and should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Scope

1. This method is a small-scale laboratory test for obtaining information regarding the coking and caking properties of coal. It is an approximate measure of that material in coal which fuses and becomes plastic on heating.[2]

Apparatus

2. The apparatus for the agglutinating-value test shall consist of the following:

(*a*) *Furnace for Carbonizing Sand-Coal Buttons.*—Vertical electric-tube furnace as specified in Section 13 (*c*) of the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (A.S.T.M. Designation: D 271) of the American Society for Testing Materials.[3] A suitable furnace on the market is Hoskins type FA-120, Fieldner furnace. The furnace shall be provided with nickel-chromium stirrups for supporting the crucible. The furnace shall be equipped with a rheostat for maintaining a temperature of 950 C. in the crucible zone.

(*b*) *Sieves.*—The following sieves of the U. S. Standard Sieve Series conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials[4] will be required:

For preparation of coal.—Sieve No. 200 (74-micron).

For preparation of sand.—Sieve No. 45 (350-micron) and sieve No. 60 (250-micron).

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-5 on Coal and Coke.

[2] For information concerning the experimental work on which this method is based, see paper by W. A. Selvig, B. B. Beattie and J. B. Clelland, "Agglutinating-Value Test for Coal," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 741 (1933).

[3] 1933 Book of A.S.T.M. Standards, Part II, p. 269.

[4] *Ibid.*, p. 1244.

(*c*) *Porcelain Crucibles.*—The following procelain crucibles will be required:

For mixing sand and coal.—Coors high-form crucible, size 2: 52 mm. top diameter; 25 mm. bottom diameter; 43 mm. height; 55-ml. capacity; or its equivalent.

For carbonizing buttons.—Coors cylindrical crucible No. 390: 28 mm. inside diameter; 30 mm. inside height; 18-ml. capacity; or its equivalent. The carbonizing crucibles shall be selected stock free from irregularities of shape. The crucible shall be provided with a porcelain cover, Coors No. 280, 35 mm. outside diameter. Two notches should be ground in the sides of the cover where it comes in contact with the side wires of the crucible stirrup. These serve as a support for the crucible when placed in the stirrup.

(*d*) *Compression Machine for Crushing Carbonized Buttons.*—A compression testing machine for agglutinating-value test, equipped with constant-speed motor arranged for reversing, shall be used.[1] The machine shall be capable of applying the load to the test specimen at a continuous rate of approximately 20 kg. per minute. The dial shall be marked in metric units, graduated in tenths, up to 25 kg. The machine shall be calibrated frequently in order to determine its accuracy. Rubber pads $\frac{3}{8}$ in. in thickness shall be cemented on the plates of the compression cage to equalize the pressure over any irregularities in the surfaces of the carbonized buttons. These pads shall be cut from the small end of a No. 12 rubber stopper.

(*e*) *Sand-Coal Button Compressor.*—The button compressor for compressing the sand-coal mixture in the carbonizing crucible can be assembled in the laboratory and shall be weighted to give a pressure of 3500 g. on the sand-coal mixture. The lower end of the compressor shall fit snugly, without binding, into the crucible so that the entire load of 3500 g. is applied to the mixture of sand and coal.

Calibration of Furnace

3. A thermocouple shall be installed permanently in the electric-tube furnace. It shall be inserted through the bottom of the furnace so that the hot junction is just below the bottom of the porcelain crucible. To calibrate the furnace one of the porcelain crucibles shall be filled with sand and placed in the stirrup and inserted into the furnace. A thermocouple shall be placed in the sand so that the end of the protection tube is in contact with the bottom of the cru-

---

[1] A Riehlé compression testing machine for agglutinating-value test, or its equivalent, is satisfactory.

cible. The furnace rheostat shall then be adjusted until a constant temperature of 950 C. is registered by the thermocouple in the crucible. The temperature of the fixed thermocouple of the furnace shall then be recorded, and this temperature corresponds to 950 C. in the crucible zone when a crucible is in the furnace. The stirrup and crucible shall then be removed and it will be noted that the fixed furnace thermocouple will then register a drop of temperature of approximately 30 C. This drop in temperature of the furnace thermocouple is due to radiation from the end of the thermocouple protection tube to the cold end of the furnace tube. The temperature registered by the furnace thermocouple shall be recorded, and this temperature corresponds to 950 C. in the crucible zone when there is no crucible in the furnace.

Sand

4. The sand to be used for mixing with the coal shall be natural silica sand from Ottawa, Ill. As purchased, it shall be graded to pass a No. 40 sieve and be retained on a No. 60 sieve. This sand may be obtained from the Ottawa Silica Company, Ottawa, Ill.

Laboratory Preparation of Sand

5. The sand shall be carefully graded in the laboratory and that portion passing a No. 45 sieve and retained on a No. 60 sieve shall be kept for the test. This graded portion shall be cleaned by placing it in a large-mouthed bottle, shaken vigorously with water, and the turbid water decanted; this operation shall be repeated five times, after which the sand shall be boiled with dilute HCl (1:1) for 30 minutes. After decanting the acid, the sand shall be transferred to a Büchner filter and washed with water until free of chlorides. The sand shall then be dried thoroughly and transferred to a covered container.

Preparation of Coal

5. The coal for the test shall be prepared by crushing air-dry coal to just pass a No. 200 sieve (74-micron). If a ball mill is used for grinding, about 200 g. of air-dry, 20-mesh coal shall be ground for 15 minutes. The coal shall then be passed through a No. 200 sieve (74-micron) and the oversize crushed on a bucking board to pass the sieve. If a ball mill is not available, the 20-mesh coal shall be ground to pass the No. 200 sieve (74-micron) by means of a bucking board. The grinding of the oversize and sieving shall be done in successive stages, and excessive grinding avoided. The 200-mesh coal shall be kept in a well-stoppered container.

Test Procedure

6. (*a*) *Sand-Coal Mixture Ratios.*—The agglutinating-value tests shall be made on freshly-prepared samples of coal at the following ratios of sand to coal: 15 parts sand, 1 part coal; 20 parts sand, 1 part coal; 25 parts sand, 1 part coal; and 30 parts sand, 1 part coal. The weight of each mixture shall be maintained constant and shall be 20 g. The amount of sand and coal for individual determination for these ratios shall be as follows:

RATIO, SAND TO COAL	WEIGHT OF SAND, G.	WEIGHT OF COAL, G.
15:1	18.750	1.250
20:1	19.048	0.952
25:1	19.231	0.769
30:1	19.355	0.645

(*b*) *Preparation of Sand-Coal Mixture.*—The sand shall be weighed into a No. 2 Coors high-form crucible and moistened with one drop of glycerine weighing 0.07 g. A drop of glycerine of this weight can be delivered from a suitable burette. The glycerine shall be mixed with the sand by stirring for 1 min. The weighed portion of coal shall then be added and the mixture stirred for 2 min. It is important that both of these mixing operations be performed in a thorough manner. To do this the following procedure shall be used for both mixing operations: The crucible, resting on a table, shall be turned with the left hand in a counter-clockwise direction. At the same time, a small spatula held in the right hand in nearly a vertical position shall be drawn repeatedly from the bottom of the crucible towards the top and simultaneously moved horizontally in a clockwise direction around the side of the crucible.

(*c*) *Preparation of Button.*—The mixture shall be carefully transferred into a Coors No. 390 cylindrical crucible and the top leveled by means of a square-end spatula. The mixture shall then be compressed in the crucible for 30 seconds under a weight of 3500 g. by means of the compression apparatus. After compression, the empty space at the top of the crucible shall be filled with a loose blanket of carbonized coal and sand obtained from crushed buttons from previous tests made with 15 parts sand to 1 part coal. After placing the cover on the crucible, it shall be placed in the crucible stirrup, and inserted into the furnace which has been regulated to a temperature of 950 C. ± 10 C. in the crucible zone. The crucible shall be left in the furnace for 20 min.

(*d*) *Carbonizing Button.*—The furnace thermocouple will record a temperature drop of from 40 to 80 C. in about 1 min. after the charge is inserted, depending on the position of the thermocouple in relation to the crucible. The temperature will then rise gradually. The furnace rheostat shall then be adjusted so that a temperature corresponding to 950 C. ± 10 C. in the crucible zone is reached 15 min. after the charge is inserted. This temperature shall be maintained during the last 5 min. of the carbonization period.

(*e*) *Crushing Button.*—After carbonizing the button for exactly 20 min., the stirrup and crucible shall be removed from the furnace and suspended in the air until the crucible has cooled to a temperature at which it can be handled with the fingers. The crucible shall then be removed from the stirrup and allowed to cool to room temperature. The blanket of loose carbonized material shall be poured off without removing the carbonized button from the crucible. The crucible shall then be inverted over a piece of No. 00 sandpaper and the button gently rubbed to remove any irregularities on the top surface. The button shall then be removed from the crucible and placed in the compression machine so that the sanded surface rests on the lower rubber pad. The button shall be carefully centered in the cage of the machine and then crushed. The crushing strength as registered on the dial of the machine shall be recorded to the nearest 0.1 kg.

Number of Tests

7. Six buttons shall be carbonized and crushed for each of the ratios of sand to coal. An additional button shall be carbonized at the 15 to 1 ratio and sectioned by cutting it in half, from top to bottom, by means of a spatula. This sectioned button shall be examined for the presence of cavities or other heterogeneous structures. If such cavities are found to occur, the buttons at the 15 to 1 ratio shall be designated as abnormal buttons. Such abnormal buttons are not suitable test specimens for determination of crushing strength.

Calculation

8. The average agglutinating value of each set of six buttons shall be calculated and the variations of the individual buttons from this average determined. If all six buttons are within 10 per cent of the average value, this value shall be taken as the agglutinating value. If one button shows a difference greater than 10 per cent of the average, the value for this button shall be discarded and the average of the five remaining buttons shall be taken as the agglutinating value. If more than one button show variations in excess of 10 per cent of the average value, the test shall be considered as unsatisfactory, the results discarded, and another test made on six buttons.

Report

9. (*a*) The agglutinating values for the different ratios of sand to coal shall be reported to the nearest tenth of a kilogram as follows:

Ratio, Sand to Coal	Agglutinating Value, kg.
15:1	....
20:1	....
25:1	....
30:1	....

(*b*) For comparing agglutinating values of different coals it is convenient to plot the agglutinating values for each coal against the sand-coal ratios and establish a curve for each coal by connecting the four points.

REPORT OF SECTIONAL COMMITTEE
ON
CLASSIFICATION OF COALS

The Sectional Committee on Classification of Coals, functioning under the procedure of the American Standards Association, held two meetings within the year: the annual meeting at the time of the American Institute of Mining and Metallurgical Engineers' meeting in New York City on February 22, 1934, and a special meeting at the U. S. Bureau of Mines in Pittsburgh, Pa., on April 2, 1934.

Culminating six years of fact-finding and research on origin, properties, and uses of coal, the committee has developed tentative specifications for the classification of coals according to rank and grade.

The classification of coals according to rank is based on the composition and properties of coal with emphasis on the properties which vary in the progressive alteration of coal in the natural series from lignite to anthracite. This classification is determined largely by nature and is not affected by the ash or sulfur of the coal.

The classification of coals according to grade depends primarily upon the amount and nature of the impurities. The grade of a coal can be modified by cleaning and preparation. In the tentative specifications the grade of a coal is determined by the calorific value, ash, sulfur, and ash-softening temperatures of the coal as sold.

These specifications are first approximations and the committee will continue to work on their further development and revision during the coming year.

Eleven papers giving the results of the past two years of experimental work sponsored by the committee were presented at the Fourth Symposium on the Classification of Coal held at the February, 1934, meeting of the American Institute of Mining and Metallurgical Engineers. These papers and the discussions will be published in the 1934 *Transactions* of the Coal Division of the Institute. They are listed at the end of this report together with references to other papers pertaining to coal classification published elsewhere. These papers comprise a valuable addition to our knowledge of the properties of coal.

The following officers were elected for the ensuing two-year period: Chairman, A. C. Fieldner; vice-chairman, H. J. Rose; secretary, C. B. Huntress; executive committee, George H. Ashley, W. H. Cunningham, W. H. Fulweiler, R. E. Gilmore, and E. W. Parker. The Technical Committees on Scientific Classification and on Use Classification were merged into a single committee designated the Technical Committee on Coal Classification.

The officers of the merged technical committee on classification elected for the ensuing two years are: Chairman, H. J. Rose; vice-chairman, T. W. Harris, Jr.; secretary, W. A. Selvig. M. M. Leighton, Director of the State Geological Survey of Illinois resigned in favor of F. H. Reed of the same organization. Mr. Reed was appointed to all of the technical committee assignments of Mr. Leighton. Miss Taisia Stadnichenko of the sectional committee was appointed a member of the Technical Committee on Coal Classification.

ACTIVITIES OF TECHNICAL COMMITTEES

The technical committees and subcommittees held two group meetings, one in Pittsburgh, Pa., on October 26 and 27, 1933, and the other in New York City on February 20 and 22, 1934.

Technical Committee on Scientific Classification (H. J. Rose, chairman).—Subcommittee I on Nature, Location and Mode of Occurrence of Coal was discontinued and work along this line was taken over by Subcommittee V on Boundary Lines for Coal Classification.

Subcommittee II on Origin and Composition of Coal and Methods of Analysis presented Report No. 7 (a revision of Report No. 5), "Recommendations on Sampling and Testing Coal for Classification." This report with certain modifications was accepted by the technical committee and the methods recommended were incorporated in the Tentative Specifications for Classification of Coals by Rank and for Classification of Coals by Grade which are appended to this report.[1] The Illinois Geological Survey has made a detailed study (**1,2,3,4**)[2] of the specific gravity and mineral matter of Illinois coals in relation to unit coal values and ash correction formulas, and the Mineral Industries Experiment Station of Pennsylvania State College is making a study of the ash-forming minerals in coal (**5**). The Coal Research Laboratory of the Carnegie Institute of Technology has two valuable papers on the fundamental composition of coal (**6,7**) and the Research Council of Alberta has investigated the oxidation of coal while drying for analysis and the influence of oven-humidity in the accelerated slacking test of coal (**8,9**). The Mines Department of Canada is continuing its study of the friability and grindability of coal (10) and also is developing an agglomerating test (11) that is being considered in connection with classification of low-rank coals. The U. S. Bureau of Mines has continued its study of methods for determining ash corrections (12), the friability (13) and grindability (14) of coals; and of the agglutinating (15), plastic (16), and coking properties of different ranks and types of coals (17).

---

[1] See pp. 834 and 841.—ED.

[2] The boldface numbers in parentheses refer to the reports and papers given in the list of references appended hereto, see p. 467.—ED.

Subcommittee III on Proposed and Used Classifications of Coals, and Subcommittee IV on Tentative Classification of Coals have been discontinued and their work has been taken over by Subcommittee V on Boundary Lines for Coal Classification.

Subcommittee V on Boundary Lines for Coal Classification has been very active in making a special study of disputed boundary lines between classes of coal. The work of this committee has been conducted by the U. S. Bureau of Mines (18), the State Geological Survey of Illinois, the Anthracite Institute (19), the Mines Department of Canada and the Associate Committee on Coal Classification of the National Research Council of Canada. Thousands of coal analyses were tabulated and studied and many additional samples were analyzed. As a result of this work, a report was submitted by this subcommittee giving an outline and specifications for the classification of coals according to rank. This report with certain revisions was adopted by the technical committee and forms the basis of the appended report by the technical committee.

Technical Committee on Coal Classification (H. J. Rose, chairman).—This committee is the new merged committee which has taken over the work of the Technical Committees on Scientific and Use Classification of Coals.

Subcommittee VI on Correlation of Scientific Classification with Use Classification of Coals which was appointed at the beginning of the year has made a careful study of the requirements of coals for various uses as indicated in the extended series of papers that have been published in the past six years. On the basis of this information and of other studies made by the subcommittee a report has been submitted containing a comprehensive table which outlines the various factors that may be considered in the selection of a coal for any specific use. After further revision, this table will be published in a subsequent report of the committee.

The Tentative Specifications for Classification of Coals by Grade, appended hereto,[1] is to be regarded as only a beginning in grade specifications. Other properties such as friability, grindability, screen size and caking properties are now under consideration and specifications will be recommended as soon as agreement is reached on methods of test. Committee D-5 on Coal and Coke of the American Society for Testing Materials is cooperating in the standardization of these tests.

---

[1] See p. 841.—ED.

Technical Committee on Nomenclature (E. A. Holbrook, chairman).—This technical committee which was appointed a year ago has given consideration to the names which should be given to the various ranks of coal as outlined by the Technical Committee on Scientific Classification. In order to avoid confusion in the literature of American coal classification, the committee decided to follow existing practice as nearly as possible in the naming of classes and groups of coals. American coals are divided into four classes, namely, anthracitic, bituminous, subbituminous and lignitic coal. These classes are subdivided into a total of thirteen groups as given in the appended report of the technical committee. This classification has been incorporated in the Tentative Specifications for Classification of Coals by Rank.[1]

RECOMMENDATIONS AFFECTING STANDARDS

Proposed Tentative Specifications for Classification of Coals by Rank.—It is recommended that these specifications, appended hereto,[1] be accepted by the Society for publication as tentative, and be submitted to the American Standards Association for approval as American Tentative Standard.

Proposed Tentative Specifications for Classification of Coals by Grade.—It is recommended that these specifications, appended hereto,[2] be accepted by the Society for publication as tentative, and be submitted to the American Standards Association for approval as American Tentative Standard.

The above recommendations have been submitted to letter ballot of the committee, which consists of 29 members, with the following results:

Items	Affirmative	Negative	Not Voting
Tentative Specifications for Classification of Coals by Rank, including the names given to the classes and groups of coals	26	2	1
Tentative Specifications for Classification of Coals by Grade	27	1	1

This report has been submitted to letter ballot of the committee, which consists of 29 members; 28 members returned their ballots, all of whom have voted affirmatively.

---

[1] See p. 834.—ED.

[2] See p. 841.—ED.

Respectfully submitted on behalf of the sectional committee,

A. C. FIELDNER,
Chairman.

C. B. HUNTRESS,
Secretary.

REFERENCES

(1) G. H. Cady, D. R. Mitchell and L. C. McCabe, "A Preliminary Report on Unit Coal: Specific Gravity Curves of Illinois Coals," Paper read at February, 1934, meeting of Coal Division, Am. Inst. Mining and Metallurgical Engrs., New York City.

(2) G. H. Cady and O. W. Rees, "Unit Coal as a Basis of Coal Standardization as Applied to Illinois Coals," Paper read at February, 1934, meeting of Coal Division, Am. Inst. Mining and Metallurgical Engrs., New York City.

(3) Gilbert Thiessen, "The Ash-to-Mineral-Matter Correction in Coal Analyses (A Study Based upon Coal-Ash Analyses)," *Contribution 68*, Coal Division, Am. Inst. Mining and Metallurgical Engrs. (1934).

(4) Gilbert Thiessen, "Proposed Simplification of the Parr Unit Coal Formula," *Fuel in Science and Practice*, Vol. 12, p. 403 (1933).

(5) A. W. Gauger, E. P. Barrett and F. J. Williams, "The Mineral Matter in Coal: A Preliminary Report," Paper read at February, 1934, meeting of Coal Division, Am. Inst. Mining and Metallurgical Engrs., New York City.

(6) H. H. Lowry, "Thermal Decomposition of the 'Coal Hydrocarbon,'" *Industrial and Engineering Chemistry*, Vol. 26, p. 320 (1934).

(7) H. H. Lowry, "The Chemical: Coal," *Industrial and Engineering Chemistry*, Vol. 26, p. 133 (1934).

(8) E. Stansfield, W. A. Lang and K. C. Gilbart, "Oxidation of Coal and Its Relation to the Analysis of Coal," *Contribution 69*, Coal Division, Am. Inst. Mining and Metallurgical Engrs. (1934).

(9) Edgar Stansfield and K. C. Gilbart, "Effect of Oven Humidity on Accelerated Weathering Tests of Coal," *Technical Publication No. 543*, Coal Division, Am. Inst. Mining and Metallurgical Engrs. (1934).

(10) C. E. Baltzer and H. P. Hudson, "A Method for Rating the Grindability or Pulverizability of Coal, Developed by the Fuel Research Laboratories, Department of Mines, Canada," *Report No. 737–1* (Advance Section of Fuels and Fuel Testing, 1932) Canada Department of Mines, Mines Branch (1933).

(11) R. E. Gilmore, G. P. Connell and J. H. H. Nichols, "Significance and Interrelation of the Terms Coking, Caking, Agglutinating, and Agglomerating, as Applied to the Classification of Coals," Paper read at February, 1934, meeting of Coal Division, Am. Inst. Mining and Metallurgical Engrs., New York City.

(12) E. S. Herzog, "Application of Ash-Correction Formulæ to Alabama Coals," *Fuel in Science and Practice*, Vol. 12, p. 109 (1933).

(13) H. F. Yancey and R. E. Zane, "Comparison of Methods for Determining the Friability of Coal," U. S. Bureau of Mines *Report of Investigation 3215* (1933).

(14) H. F. Yancey, O. L. Furse and R. A. Blackburn, "Estimation of the Grindability of Coal," Paper read at February, 1934, meeting of Coal Division, Am. Inst. Mining and Metallurgical Engrs., New York City.

(15) W. A. Selvig, B. B. Beattie and J. B. Clelland, "Agglutinating-Value Test for Coal," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 741 (1933).

(16) J. D. Davis, F. W. Jung, B. Juettner and D. A. Wallace, "Plastic Properties of Coking Coals," *Industrial and Engineering Chemistry*, Vol. 25, p. 1269 (1933).

(17) A. C. Fieldner, J. D. Davis, D. A. Reynolds and C. R. Holmes, "High-Temperature Carbonizing Properties of Coal," *Industrial and Engineering Chemistry*, Vol. 25, p. 300 (1934).

(18) W. A. Selvig, W. H. Ode and A. C. Fieldner, "Classification of Coals of the United States According to Fixed Carbon and B.t.u.," *Technical Publication No. 527*, Coal Division, Am. Inst. Mining and Metallurgical Engrs. (1934).

(19) H. G. Turner, "Anthracites and Semi-Anthracites of Pennsylvania," Paper read at February, 1934, meeting of Coal Division, Am. Inst. Mining and Metallurgical Engrs., New York City.

(20) W. L. Keene, H. G. Turner and G. S. Scott, "Reactivity of Anthracite with Carbon Dioxide," Paper read at February, 1934, meeting of Coal Division, Am. Inst. Mining and Metallurgical Engrs., New York City.

(21) C. C. Wright and A. W. Gauger, "The Hydrogenation of Coal," *Industrial and Engineering Chemistry*, Vol. 26, p. 164 (1934).

(22) Irvin Lavine, "Progress in Low-Rank Coals," *Industrial and Engineering Chemistry*, Vol. 26, p. 154 (1934).

(23) H. J. Rose, "Coal Classification," *Industrial and Engineering Chemistry*, Vol. 26, p. 140 (1934).

(24) E. J. Burrough, E. Swartzman and R. A. Strong, "Classification of Coals Using Specific Volatile Index," *Report No. 725–2* (Advance Section of Fuels and Fuel Testing, 1930–31, p. 36) Canada Department of Mines, Mines Branch (1933).

(25) E. Swartzman, E. J. Burrough and R. A. Strong, "A Laboratory Test on Coals for Predicting the Physical Properties of the Resultant By-Product Coke," *Report No. 737–2* (Advance Section of Fuels and Fuel Testing, 1932) Canada Department of Mines, Mines Branch (1933).

EDITORIAL NOTE

The proposed Tentative Specifications for Classification of Coals by Rank, including the names given to the classes and groups of coals, and for Classification of Coals by Grade were accepted for publication as tentative and appear on pages 834 and 841, respectively.

REPORT OF THE TECHNICAL COMMITTEE ON SCIENTIFIC CLASSIFICATION

This report summarizes the activities of the Technical Committee on Scientific Classification since its organization, and submits the proposed Tentative Specifications for Classification of Coals by Rank, appended hereto,[1] which are respectfully presented to the Sectional Committee on Classification of Coals and recommended for publication as tentative.

Formation and Meetings.—The Technical Committee on Scientific Classification was appointed by the Executive Committee on July 14, 1927. The first meeting was held on November 17, 1927, and formal meetings have been held regularly, twice a year, since that time. The personnel and officers of the committee and its various subcommittees are given later in this report.

Progress Reports and Publications.—The minutes of meetings, together with all subcommittee reports, are contained in the series of mimeographed General Circulars Nos. 1 to 43, covering coal classification committee work, which are on file in the offices of the American Society for Testing Materials, Philadelphia, Pa., and the American Standards Association, New York City.

Annual progress reports, including bibliographies of papers relating to coal classification which have been written by committee members and others, will be found in the Reports of the Sectional Committee on Classification of Coals published annually since 1929 in the *Proceedings* of the American Society for Testing Materials, Vols. 29 to 33, Part I (1929 to 1933). The accompanying current report contains a list of additional papers, including those presented before the Gas and Fuel Division of the American Chemical Society at Chicago in September, 1933, also papers prepared for the February, 1934, meeting in New York City of the Coal Division of the American Institute of Mining and Metallurgical Engineers, together with additional papers presented elsewhere during the year.

Scope of Assigned Work.—The committee was charged with developing a fundamental system or systems for the classification of American coals, based principally on inherent chemical and physical properties, constitution and geological considerations. Through Canadian experts on the committee, and by close cooperation with th Associate Committee on Coal Classification and Analysis, of th National Research Council of Canada, full information on the characteristics of Canadian coals has been available to supplement th study of the coals of the United States.

---

[1] See p. 834.—Ed.

Complexity of Problem.—Coal is a natural product derived from a variety of original ingredients which were subsequently subjecte to various conditions such as biochemical and environmental change in the early stages of formation, the nature and thickness of overlying strata, heat and pressure effects due to rock movements an igneous intrusions, infiltering minerals, and weathering in some cases

Coals of all ranks from lignite to anthracite are commercially produced in the United States from some 6000 mines, located in mor than 30 states. The average annual production of about 500 million tons greatly exceeds the tonnage shipments of any other commodity or any natural group of commodities. The combined coal reserves o the United States and Canada form two-thirds of the world's known coal supply.

The need for systematic classification of such an important and widely used natural product as coal has been obvious, and many systems of classification have been proposed by individuals during the past 100 years. Certain of these systems have become widely known, and have served a useful purpose in providing broad, general designations for various ranks of coal. However, they have not received widespread official adoption, and in general they are not sufficiently detailed to meet modern needs.

It was soon recognized that coals could be usefully classified according to their inherent composition and properties, along three different lines, as follows:

1. By rank, that is, according to the degree of metamorphism, or progressive alteration in the natural series from lignite to anthracite;

2. By type, that is, by varieties such as common, cannel, boghead or algal, and splint coals, and

3. By grade, that is, according to the nature and amount of impurities present, screen size, etc.

Previously Proposed Systems of Classification.—Almost every imaginable characteristic of coal has been suggested or used as a basis of classification. Only those classifications relating directly to the inherent properties or characteristic behavior of coals will be considered here. These include proximate and ultimate analysis, calorific value, mineralogic description, purity, coking properties, strength, ability to resist weathering, combustion behavior, etc.

The work of critically comparing the various systems of coal classification was seriously hindered by the many purity bases recommended and used by the various authors. Systems of classification are variously based on coal that has been oven-dried, air-dried, or containing typical moisture as mined. They may be based on coal calculated ash-free, or adjusted to some uniform ash figure, or calculated mineral-matter-free by any one of several special formulas designed to reduce the average errors of the ordinary ash-free calculation. Furthermore, some systems recommend calculation to the sulfur-free and even nitrogen-free basis.

To facilitate the work of direct comparison of different systems of coal classification, a special chart was devised. On this chart it was possible to plot coals according to their proximate analysis, ultimate analysis and calorific value, on any or all purity bases, and to simultaneously show the locus of various boundary lines, ratios and formulas that have been suggested, together with the physical properties of the coals.

Proximate Analysis and B.t.u. versus Ultimate Analysis, as a Basis for Classification by Rank.—In America, from an early date, proximate analysis seems to have been preferred to ultimate analysis for the classification of coals according to rank. It has been known for some years that a similar classification of coals could be obtained by plotting them either according to their fixed carbon (or volatile matter) contents and B.t.u., or according to their ultimate analyses. After graphically studying the analyses of hundreds of American and foreign coals of all ranks, it was concluded that similar results were obtained by either method. Each appeared to have minor advantages and disadvantages, the choice being a matter of convenience and expediency. The Technical Committee on Scientific Classification has preferred the combination of fixed carbon and B.t.u., since (1) these figures are nearly always available or may be readily and inexpensively obtained, and (2) since this conforms more nearly to long established American usage. Careful study indicated that with regard to average accuracy and reproducibility of results, fixed carbon and B.t.u. determinations are as satisfactory for coal classification purposes as ultimate analyses.

Moisture Basis.—After extended and thorough studies, the committee reached the conclusion that the typical or bed moisture content must be recognized when classifying lignitic, subbituminous, and the higher-moisture bituminous coals, but that it was in general unnecessary to use the moist basis when classifying the high-rank bituminous and anthracitic coals.

Mineral-Matter-Free Basis.—When classifying coals according to rank, it is desirable to compare them on a uniform basis, calculated free of mineral impurities. For accurate work, the ordinary "ash-free" basis is not satisfactory, since the weight of ash left in the standard determination is distinctly less than the weight of mineral impurities present in the raw coal. This is due to loss of water from hydrated minerals, carbon dioxide from carbonates, conversion of pyrites to iron oxide, etc.

Studies have been made of float-and-sink methods, and acid treatments to obtain low-ash or ashless coal, and exhaustive studies have been made of several average correction formulas which can be applied to the regular analyses. Calculation to the mineral-matter-free basis is specified for the classification of coal by rank.

Agglutinating or Agglomerating Index.—It has been found desirable to include agglutination requirements in establishing the boundary between the anthracitic and bituminous classes, and between the bituminous and subbituminous classes. An agglomeration test is also being investigated and may be substituted for the agglutinating test if it proves more satisfactory.

Weathering or Slacking Index.—Most low-rank coals have a characteristic tendency to "slack" or break up, when exposed to weathering during storage or shipment. This behavior is so characteristic and important that it has been included as a supplementary requirement in differentiating between the bituminous and subbituminous classes.

Since there was no established method, a suitable test procedure had to be worked out, and its possibilities and significance established. Weathering data have been obtained on a large number of typical American coals.

Boundary Line Problems.—It is a relatively easy matter to pick out and approximately describe a number of typical varieties of coal which are distinct in character, and clearly entitled to recognition. However, such varieties grade into each other by degrees. When all of the enormous coal reserves of the United States and Canada are studied, it is found that there is a lack of abrupt natural divisions in the properties of coal when arranged according to rank.

This general situation is of course to be expected when classifying natural commodities, and has not prevented the successful classification of other commodities such as ores, grains, fruits, and textile fibers.

During the past seven years of committee activity, a truly enormous amount of systematic study has been made of thousands of analyses and tests of coals from practically every coal-bearing area in the United States and Canada. Areas for which existing analyses were questionable have been resampled and tested, through the coöperation of various governmental agencies in the two countries.

As a result of this thorough study, the committee believes that the Tentative Specifications for Classification of Coals by Rank, appended hereto,[1] form as good a classification for the purposes intended, as can be developed from our present technical information on the subject. Each boundary line that is recommended has been reached after considering many factors, and it is felt that further revision will not be required except on the basis of new information, or due to future standardization of certain test methods.

Nomenclature.—The committee has been committed to a policy of classifying coals on the basis of inherent properties, and has not attempted to develop a classification merely to fit existing names. This technical committee has no jurisdiction over the names of the varieties of coal that have been defined, as this is the function of the Technical Committee on Nomenclature.

Classification by Type.—Considerable progress has been made on specifications for the classification of coals by type, that is, by varieties such as common, cannel, boghead or algal, splint, etc. However, such specifications are not ready for submission to the sectional committee at the present time.

Classification by Grade.—Specifications for the classification of coals by grade, that is, according to the amount and nature of impurities present, the screen size of coal, etc., are not referred to in this report, since such specifications have been under the jurisdiction of the Technical Committee on Use Classification.

Personnel and Officers of Committee and Subcommittees.—The personnel and officers of the technical committee and its subcommittees are as follows:

TECHNICAL COMMITTEE ON SCIENTIFIC CLASSIFICATION

H. J. Rose, chairman
W. H. Cunningham, vice-chairman
W. A. Selvig, executive secretary
W. T. Thom, Jr., secretary
G. H. Ashley
S. P. Burke
G. H. Cady
M. R. Campbell
H. N. Eavenson
A. C. Fieldner (*ex officio*)
W. H. Fulweiler
A. W. Gauger
R. E. Gilmore
T. W. Harris, Jr.
T. A. Hendricks
H. H. Lowry
E. Stansfield
R. Thiessen
H. G. Turner
F. R. Wadleigh

---

[1] See p. 834.—ED.

Subcommittee I on Nature, Location and Mode of Occurrence of American Coals

M. R. Campbell, chairman
T. W. Harris, Jr.
F. R. Wadleigh

Subcommittee II on Origin and Composition of Coal and Methods of Analysis

A. C. Fieldner, chairman
S. P. Burke
G. H. Cady
D. J. Demorest
R. E. Gilmore
C. A. Lunn
W. A. Selvig
J. D. Davis (alternate)
T. Stadnichenko
E. Stansfield
R. Thiessen

Subcommittee III on Proposed an Used Classifications of Coals

H. J. Rose, chairman
G. H. Ashley
M. R. Campbell
R. E. Gilmore
W. T. Thom, Jr.

Subcommittee IV on Tentative Classifi cation of Coals

W. T. Thom, Jr., chairman
G. H. Ashley
G. H. Cady
W. A. Selvig
E. Stansfield

Subcommittee V on Boundary Lines fo Coal Classification

W. A. Selvig, chairman
G. H. Ashley
G. H. Cady
R. E. Gilmore
T. A. Hendricks
B. R. MacKay
E. Stansfield

This report, including the proposed Tentative Specifications fo Classification of Coals by Rank, has been submitted to letter ballo of the technical committee, which consists of 20 members; 20 members returned their ballots, of whom 19 have voted affirmatively anc 1 negatively.

Respectfully submitted on behalf of the technical committee,

H. J. ROSE,
Chairman.

W. A. SELVIG,
Executive Secretary.

REPORT OF THE TECHNICAL COMMITTEE ON NOMENCLATURE

This report summarizes the activities of the Technical Committee on Nomenclature and submits a scheme of nomenclature of coal which is respectfully presented to the Sectional Committee on Classification of Coals and recommended for publication as tentative.

Personnel of Committee.—The Technical Committee on Nomenclature was appointed in April, 1933, and consists of the following members:

E. A. Holbrook, chairman
G. H. Ashley
H. N. Eavenson
W. H. Fulweiler
T. W. Harris, Jr.
T. A. Hendricks
M. M. Leighton
H. J. Rose
Edgar Stansfield
F. R. Wadleigh

Scope of Assigned Work.—The technical committee was charged with the formulation of a system of names for the various classes and groups of coals for use in classifying coals by rank. Specifically, the committee was requested to recommend names for the classes and groups of coal shown in the proposed Tentative Specifications for Classification of Coals by Rank[1] as developed by the Technical Committee on Scientific Classification.

Activities of Committee.—Ideas and suggestions on the subject of nomenclature were solicited from members of the committee by correspondence. A meeting of the Pittsburgh members of the committee was held on October 19, 1933. The members present were: E. A. Holbrook, H. J. Rose, H. N. Eavenson, and W. A. Selvig (representing A. C. Fieldner). At this meeting all suggestions submitted by members of the committee were reviewed and a preliminary scheme of nomenclature drafted. This scheme was presented in a progress report of the technical committee at the meeting of the committee held in Pittsburgh, Pa., on October 26, 1933. The minutes of this meeting are recorded in the mimeographed General Circular No. 44 which was sent to all members of the Sectional Committee and are on file in the offices of the American Society for Testing Materials, Philadelphia, Pa., and the American Standards Association, New York City.

On October 31, 1933, letters were written to every member of the committee who was not present at the October 26 meeting and these members were requested to submit their comments on the proposed scheme of nomenclature. A number of valuable suggestions were received.

---

[1] See p. 834.—Ed.

At a meeting of the technical committee held in Pittsburgh, Pa., on January 2, 1934, all the suggestions and criticisms on nomenclature of coal were reviewed and the former scheme of nomenclature was revised in accordance with the scheme presented in this report. Those present at this meeting were E. A. Holbrook, H. J. Rose, A. C. Fieldner, and W. A. Selvig.

TABLE I.—RECOMMENDED NOMENCLATURE FOR CLASSIFICATION OF COALS BY RANK.

(The limits of fixed carbon and B.t.u., and the requisite physical properties as given in this table are for reference purposes only as these come under the jurisdiction of the Technical Committee on Scientific Classification.)

Legend: F.C. = Fixed Carbon. V.M. = Volatile Matter. B.t.u. = British thermal units.

Class	Group	Limits of Fixed Carbon or B.t.u. Mineral-Matter-Free Basis	Requisite Physical Properties
I. Anthracitic	1. Meta-anthracite	Dry F.C., 98 per cent or more (Dry V.M., 2 per cent or less)	
	2. Anthracite	Dry F.C., 92 per cent or more and less than 98 per cent (Dry V.M., 8 per cent or less and more than 2 per cent)	
	3. Semianthracite	Dry F.C., 86 per cent or more and less than 92 per cent (Dry V.M., 14 per cent or less and more than 8 per cent)	Non-agglutinating[a]
II. Bituminous[c]	1. Low volatile bituminous coal	Dry F.C., 77 per cent or more and less than 86 per cent (Dry V.M., 23 per cent or less and more than 14 per cent)	
	2. Medium volatile bituminous coal	Dry F.C., 69 per cent or more and less than 77 per cent (Dry V.M., 31 per cent or less and more than 23 per cent)	
	3. High volatile *A* bituminous coal	Dry F.C., less than 69 per cent (Dry V.M., more than 31 per cent); and moist[b] B.t.u., 14,000[d] or more	
	4. High volatile *B* bituminous coal	Moist[b] B.t.u., 13,000 or more and less than 14,000[d]	
	5. High volatile *C* bituminous coal	Moist B.t.u., 11,000 or more and less than 13,000[d]	Either agglutinating or non-weathering[e]
III. Subbituminous	1. Subbituminous *A* coal	Moist B.t.u., 11,000 or more and less than 13,000[d]	Both weathering and non-agglutinating
	2. Subbituminous *B* coal	Moist B.t.u., 9500 or more and less than 11,000[d]	
	3. Subbituminous *C* coal	Moist B.t.u., 8300 or more and less than 9500[d]	
IV. Lignitic	1. Lignite	Moist B.t.u., less than 8300	Consolidated
	2. Brown coal	Moist B.t.u., less than 8300	Unconsolidated

[a] If agglutinating, classify in low-volatile group of the bituminous class.

[b] Moist B.t.u. refers to coal containing its natural bed moisture but not including visible water on the surface of the coal.

[c] Pending the report of the Subcommittee on Origin and Composition and Methods of Analysis, it is recognized that there may be non-caking varieties in each group of the bituminous class.

[d] Coals having 69 per cent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of B.t.u.

[e] There are three varieties of coal in the High-volatile *C* bituminous coal group, namely, Variety 1, agglutinating and non-weathering; Variety 2, agglutinating and weathering; Variety 3, non-agglutinating and non-weathering.

Comments.—The Technical Committee on Scientific Classification has formulated proposed Tentative Specifications for Classification of Coals by Rank.[1] In these specifications coals are broadly divided into four classes. These classes are subdivided into thirteen groups, according to fixed carbon and B.t.u. These thirteen groups allow coal to be classified by rank with reasonable accuracy. While Nature has not provided sharp boundary lines between the various ranks of coal, yet it has provided typical coals in these groups. The committee felt that its task was to provide suitable names for these classes and groups.

Much recourse was had to the dictionary to learn the value of certain prefixes proposed. There are valid objections to every prefix that has been proposed, but the several prefixes that are recommended, as for example, meta-anthracite, probably most nearly meet the needs for which they are used.

It is obvious that some commercial coal-mining districts or some coal operators may produce coal that comes below the group names by which they would like to designate their coal. This cannot be helped as the committee must adhere to a plan of considering coals from a continent-wide viewpoint.

The class and group names represent little that is new or novel. Some of the names may be open to criticism from the point of view of purity of language, but outweighing this is the fact that they are easily recognized by the present producing and consuming industries. The nomenclature submitted is based in general on the conviction that simplicity and the use of well-established names where possible, will best serve the purpose intended.

The recommended nomenclature is that given in the columns headed "Class" and "Group" in Table I. The limits of fixed carbon and B.t.u., and the requisite physical properties shown in the table are for reference purposes only as these come under the jurisdiction of the Technical Committee on Scientific Classification.

This report, including the proposed scheme of nomenclature of coal, has been submitted to letter ballot of the technical committee which consists of 10 members; 10 members returned their ballots, of whom 9 have voted affirmatively, 1 affirmatively with reservations, and none negatively.

Respectfully submitted on behalf of the technical committee,

E. A. HOLBROOK,
Chairman.

---

[1] See p. 834.—ED.

REPORT OF THE TECHNICAL COMMITTEE ON COAL CLASSIFICATION

This report submits the proposed Tentative Specifications for Classification of Coals by Grade, appended hereto,[1] which are respectfully presented to the Sectional Committee on Classification of Coals and recommended for publication as tentative. The specifications give a convenient and simple method of classifying coals according to quality as expressed by calorific value, ash and sulfur content, and ash-softening temperature. From the standpoint of use these are important factors. Specifications for screen size, resistance to breakage, caking properties, and other factors important in the use of coal for special purposes are under consideration by the committee and additional specifications will be recommended in subsequent reports.

Formation and Meetings.—A Technical Committee on Use Classification was appointed by the Executive Committee on July 14, 1927. The first meeting was held on November 17, 1927, and one or two formal meetings were held each year up to and including 1933. On February 22, 1934, it was combined with the Technical Committee on Scientific Classification, forming the present Technical Committee on Coal Classification.

Progress Reports and Publications.—The minutes of meetings, together with all subcommittee reports, are contained in a series of mimeographed General Circulars, covering coal classification committee work, which are on file in the offices of the American Society for Testing Materials, Philadelphia, Pa., and the American Standards Association, New York City.

Annual progress reports, including bibliographies of papers relating to coal classification which have been written by committee members and others, will be found in the Reports of the Sectional Committee on Classification of Coals published annually since 1929 in the *Proceedings* of the American Society for Testing Materials, Vols. 29 to 33, Part I (1929 to 1933). The accompanying current report contains a list of additional papers, including those prepared for the February, 1934, meeting in New York City of the Coal Division of the American Institute of Mining and Metallurgical Engineers, together with additional papers presented elsewhere during the year.

---

[1] See p. 841.—Ed.

Scope of Assigned Work.—The Technical Committee on Use Classification was charged with the development of classifications based principally on the uses of coal and commercial practice, and their correlation with scientific classifications. Another objective was to secure data on the different uses for coal and the requirements for these uses.

Requirements for Special Uses.—A number of papers on requirements of coal for special uses have been written by individual members of the committee, and have been published in the *Transactions* of the Coal Division of the American Institute of Mining and Metallurgical Engineers. A subcommittee is reviewing these and other recommendations with a view of tabulating the characteristics which are considered desirable in coal for specific uses.

Classification by Grade.—The Tentative Specifications for Classification of Coals by Grade, appended hereto,[1] are intended for use in conjunction with the Tentative Specifications for Classification of Coals by Rank[2] and with the classification according to Type. The latter classification is now being developed.

Personnel and Officers of Committee and Subcommittees.—The personnel and officers of the technical committee and its subcommittees is as follows:

TECHNICAL COMMITTEE ON COAL CLASSIFICATION

H. J. Rose, chairman
T. W. Harris, Jr., vice-chairman
W. A. Selvig, secretary
G. H. Ashley
S. P. Burke
G. H. Cady
M. R. Campbell
W. H. Cunningham
H. N. Eavenson
A. C. Fieldner (*ex-officio*)
S. B. Flagg
G. Francklyn
W. H. Fulweiler
A. W. Gauger
R. E. Gilmore
T. A. Hendricks
H. A. Kidder
A. E. Ellis (alternate)
H. H. Lowry
M. Macfarlane
J. B. Morrow
C. A. Owen
L. R. Page
E. W. Parker
E. B. Raiguel
T. Stadnichenko
E. Stansfield
R. Thiessen
W. T. Thom, Jr.
H. G. Turner
F. R. Wadleigh
C. P. White
C. E. Williams

---

[1] See p. 841.—ED.

[2] See p. 834.—ED.

SUBCOMMITTEES

Subcommittee I on Nature, Location and Mode of Occurrence of American Coals (Discontinued)

Subcommittee II on Origin and Composition of Coal and Methods of Analysis

A. C. Fieldner, chairman
S. P. Burke
G. H. Cady
D. J. Demorest
R. E. Gilmore
C. A. Lunn
W. A. Selvig
J. D. Davis (alternate)
T. Stadnichenko
E. Stansfield
R. Thiessen

Subcommittee III on Proposed and Used Classifications of Coal (Discontinued)

Subcommittee IV on Tentative Classifications of Coals (Discontinued)

Subcommittee V on Boundary Lines for Coal Classification

W. A. Selvig, chairman
G. H. Ashley
G. H. Cady
R. E. Gilmore
T. A. Hendricks
B. R. MacKay
E. Stansfield

Subcommittee VI on Correlation of Scientific Classification with Use Classification of Coal

T. W. Harris, Jr., chairman
G. Francklyn
S. B. Flagg
J. B. Morrow
M. Macfarlane
R. E. Gilmore

This report, including the proposed Tentative Specifications for Classification of Coals by Grade, has been submitted to letter ballot of the technical committee, which consists of 32 members; 29 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the technical committee,

H. J. ROSE,
Chairman.

W. A. SELVIG,
Secretary.

REPORT OF COMMITTEE D-7
ON
TIMBER

Committee D-7 on Timber, through its various subcommittees, reports the following activities:

Subcommittee I on Specifications for Timber (C. E. Paul, chairman).—This subcommittee has completed its work in connection with the Tentative Specifications for Timber Piles (D 25 – 30 T)[1] and is submitting this year completely revised specifications as appended hereto.[2] Attention is called to the fact that the objections to the former tentative specifications have now all been met and it is believed that workable specifications have been developed which are applicable to all classes of work where timber piles are used.

Subcommittee VI on Timber Preservatives (S. R. Church, chairman).—Responding to the general request that the Society develop specifications for creosote and creosote coal-tar solution, this subcommittee is presenting for publication as tentative proposed Tentative Specifications for Creosote and for Creosote Coal-Tar Solution, as appended hereto.[3] Attention is called to the fact that the proposed tentative specifications were developed in cooperation with the committees of the American Railway Engineering Association and the American Wood Preservers' Association, and are identical with the standard specifications of these associations. When adopted by the Society, the specifications will accordingly be generally accepted standard specifications for these materials.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 24 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARDS			
Specifications for Creosote	18	2	4
Specifications for Creosote Coal-Tar Solution	18	2	4
II. PROPOSED REVISION OF TENTATIVE STANDARD			
Tentative Specifications for Timber Piles (D 25 – 30 T)	21	0	3

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1148 (1930); also 1933 Book of A.S.T.M. Tentative Standards, p. 472.

[2] See p. 847.—ED.

[3] See pp. 843 and 845.—ED.

The election of officers for the ensuing term of two years resulte in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committe which consists of 24 members; 24 members returned their ballot of whom 22 have voted affirmatively, and none negatively.

Respectfully submitted on behalf of the committee,

HERMANN VON SCHRENK,
Chairman.

J. A. NEWLIN,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Creosote and for Creosot Coal-Tar Solution were accepted for publication as tentative and appear o pages 843 and 845, respectively.

The revision of the Tentative Specifications for Timber Piles was accepted The specifications in their revised form appear on page 847.

REPORT OF COMMITTEE D-8
ON
BITUMINOUS WATERPROOFING AND ROOFING MATERIALS

Committee D-8 on Bituminous Waterproofing and Roofing Materials has held two meetings during the past year: in Chicago, Ill., on June 29, 1933, and in Washington, D. C., on March 8, 1934.

Activities of Subcommittees

Subcommittee IV on Specifications (Including Analytical Methods) for Membrane Materials (C. H. Pierson, chairman).—As the result of numerous criticisms received during the past year, Subcommittee IV has developed and submitted to all members of Committee D-8 rather extensive revisions of the following four existing specifications which were published as tentative in 1933:

Tentative Specifications for Asphalt Roll-Roofing Surfaced with Powdered Talc (D 224 - 33 T)

Tentative Specifications for Roll-Roofing Surfaced with Granular Talc (D 248 - 33 T)

Tentative Specifications for Heavy Weight Asphalt Roll-Roofing and Heavy Weight Asphalt Shingles Surfaced with Mineral Granules (D 249 - 33 T)

Tentative Specifications for Asphalt Roll-Roofing and Asphalt Shingles Surfaced with Mineral Granules (D 225 - 33 T)

It is expected that at the June meeting of Committee D-8 the revised specifications,[1] which represent a complete rewriting of the present tentative standards, will be approved by the committee for reference to letter ballot and, if favorably acted upon subsequent to the meeting, will then be submitted to the Society through Committee E-10 on Standards so that they may, if possible, be published as tentative standards during the year.[2]

Subcommittee IX on Bituminous Emulsions (Lester Kirschbraun, chairman).—During the past two years, Subcommittee IX has considered the properties of emulsified asphalts for which it is believed test methods should be prepared. Where methods existed, or were

---

[1] See pp. 944 to 958.—Ed.

[2] See Editorial Note, p. 485.—Ed.

in preparation, these have been used with the necessary adaptation
The subcommittee has completed the preparation of testing procedur
for miscibility with water, determination of water, application sta
bility, and a freezing test. These tests have been incorporated i
the proposed Methods of Test for Bituminous Emulsions Intende
for Use for Waterproofing, which are published in an Appendix to thi
report for general information.[1] The properties for which test metho
must yet be devised are as follows: pliability, resistance to flow und
heat, retention of adhesion and cohesion upon immersion in wate
Further work is required before the subcommittee will be able t
report upon these latter tests.

Subcommittee X on Standard Coefficient of Expansion for Bitum
nous Products (J. S. Miller, Jr., chairman).—This subcommittee i
its report appended hereto presents for general information dat
obtained from reliable sources on the coefficient of expansion of variou
bituminous materials.

RECOMMENDATIONS AFFECTING STANDARDS

I. Adoption of Tentative Standard as Standard.—In its 1932 annua
report Committee D-8 recommended that the Tentative Method o
Analysis of Roofing Felt for Fiber Composition (D 272 – 29 T)[2] b
adopted as standard, but in view of the desire of the Society to effec
economies in publication that year it suggested that publication a
standard be deferred until 1933, when the next edition of the Book o
Standards would be issued. The results of the committee's lette
ballot on this recommendation were reported in the 1932 annua
report. Since, however, the methods were not referred to lette
ballot of the Society as expected, Committee D-8 again recommend
that this tentative method be approved for reference to letter ballo
of the Society for adoption as standard and reports as follows on th
letter ballot which it took in 1932: 38 voting members returned thei
ballots of whom 31 have voted affirmatively, 2 negatively and
marked their ballots not voting.

II. Tentative Standards Continued as Tentative.—Committee D-
has the following two tentative standards which have been continue
as tentative without revision since 1929: Tentative Method of Tes
for Coarse Particles in Bituminous Materials by Means of Elutriatio
(D 313 – 29 T) and Tentative Specifications for Asphalt for Use i
Constructing Built-Up Roof Coverings (D 312 – 29 T). It is considere

---

[1] These methods were presented to Committee E-10 on Standards subsequent to the annua
meeting for publication as tentative, see Editorial Note, p. 485.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 724 (1929); also 1933 Book of A.S.T.M
Tentative Standards, p. 697.

advisable to continue these as tentative as they are at present in process of revision.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee which consists of 49 voting members; 35 members returned their ballots, of whom 33 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

J. M. WEISS,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

The Tentative Method of Analysis of Roofing Felt for Fiber Composition was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appears in the 1934 Supplement to Book of A.S.T.M. Standards, page 144.

Recommendations to Committee E-10 on Standards.—Subsequent to the annual meeting Committee D-8 on Bituminous Waterproofing and Roofing Materials presented to the Society through Committee E-10 on Standards the following additional recommendations referred to in the report which were accepted by Committee E-10 on August 22, 1934:

Proposed Tentative Methods of Test for Emulsified Asphalts Intended for Use for Waterproofing, which methods have been combined with other tests for bituminous emulsions prepared by Committee D-4 on Road and Paving Materials under the title, "Tentative Methods of Testing Emulsified Asphalts," were accepted. The combined methods appear on page 926.

Revisions of the Tentative Specifications for Asphalt Roll-Roofing Surfaced with Powdered Talc, for Asphalt Roll-Roofing Surfaced with Granular Talc, for Heavy Weight Asphalt Roll-Roofing and Heavy Weight Asphalt Shingles Surfaced with Mineral Granules, and for Asphalt Roll-Roofing and Asphalt Shingles Surfaced with Mineral Granules were accepted. The specifications in their revised form have been issued under the titles, "Tentative Specifications for Asphalt Roofing Surfaced with Powdered Talc or Mica, for Asphalt Roofing Surfaced with Fine Mineral Granules, for Asphalt Roofing Surfaced with Coarse Mineral Granules, and for Asphalt Shingles Surfaced with Coarse Mineral Granules," and appear on pages 944 to 958, inclusive.

REPORT OF SUBCOMMITTEE X ON STANDARD COEFFICIENT O EXPANSION FOR BITUMINOUS PRODUCTS

Subcommittee X on Standard Coefficient of Expansion f Bituminous Products circularized many members of the Society wi a questionnaire, requesting any data they might have either dete mined themselves or obtained from reliable sources on the coefficie of expansion of bituminous materials.

Values for those materials which could be definitely identified to class are given below:

Material		Temperature Range, deg. Fahr.	Coefficient of Expansion per 1 F.	
Crude tars	Horizontal coal tar	60 to 150	0.00027 to 0.000305	
	Vertical coal tar	60 to 150	0.000355 to 0.00037	
	Coke oven tar	60 to 150	0.00032 to 0.00034	
	Low temperature tar	60 to 150	0.00042	
	Light water-gas tar	60 to 150	0.00035 to 0.00037	
	Heavy water-gas tar	60 to 150	0.00031 to 0.00032	
			Coal Tar	Water-Gas Tar
Tar road materials and pitch	Cutback products	60 to 180	0.00033 to 0.00037	0.00034 to 0.0003
	Patching materials	60 to 180	0.00033	0.000328 to 0.0003
	Hot application	100 to 200	0.0003 to 0.00035	0.00029 to 0.0003
	Cements	100 to 300	0.0003	0.0003
	Pitches	200 to 300	0.000255 to 0.00028	0.000255 to 0.0002
Asphaltic road material	Road oils	60 to 180	0.0004 to 0.00041	
	Cutbacks	60 to 180	0.0004 to 0.00042	
	Hot application	200 to 300	0.00036	
	Cements	200 to 350	0.00033 to 0.00034	
Solid asphalts		32 to 140	0.00035 to 0.00039	
		60 to 250	0.00033 to 0.00039	
		200 to 400	0.00033 to 0.00035	
		250 to 350	0.000362 to 0.000384	
		350 to 450	0.000378 to 0.000399	
		60 to 450	0.00036 to 0.000382	
Petroleum asphalts and fluxes[a]		60 to 150	0.00035	
		60 to 250	0.00036	
		60 to 350	0.00037	
		60 to 450	0.00038	

[a] Values taken from the National Bureau of Standards *Miscellaneous Publication No.* 97, p. 6.

The principal variations are apparently related to the followin factors:

Source and process (tars especially).
Consistency.
Temperature range:
- (*a*) Entirely within solid state.
- (*b*) From solid to about liquid.
- (*c*) From solid to very high temperature.
- (*d*) Entirely within liquid state.

The largest range of coefficient in the crude tars is the minimum of 0.00027 and the maximum of 0.00042. Over a temperature range of 60 to 150 F. and using a mean of these extremes would result in an average error in volume correction of about 0.9 per cent. Similarly for tar road materials and pitch the minimum is 0.000255 and maximum of 0.00037 so an average figure would cause a possible error of 1.0 per cent.

In the asphaltic road material group we have a maximum range of from 0.00033 to 0.00042 so using the average of these extremes over a range from 60 to 300 F. we would have an error of 1.0 per cent.

In the solid asphalt group the maximum range is 0.00033 to 0.000399 and using the average over a range of from 60 to 450 F. we would have an error of 1.19 per cent.

These possible errors for asphaltic products are greater than those given in the Bureau of Standards *Miscellaneous Publication No. 97*, page 6, where the maximum error is 0.8 per cent for temperatures between 400 and 500 F. The tables given in this publication are for petroleum asphalts and fluxes and are based upon unpublished measurements made by the Bureau on 25 samples within the range of 32 to 176 F. and 2 samples within the range of 60 to 400 F.

The subcommittee therefore feels that the cooperation of the National Bureau of Standards should be sought to the extent of determining values upon groups of liquid as well as semisolid and solid bituminous products (both tar and asphaltic products); the committee to arrange to supply the Bureau with samples of known source, process, consistency (to include viscosity, float or penetration and melting point when possible), and specific gravity.

Respectfully submitted on behalf of the subcommittee,

J. S. MILLER, JR.,
Chairman.

REPORT OF COMMITTEE D-9
ON
ELECTRICAL INSULATING MATERIALS

Two meetings, each of two days duration have been held Committee D-9 and its subcommittees during the year, as follow At the Hotel New Yorker, New York City, October 19 and 20, 193 and at the Benjamin Franklin Hotel, Philadelphia, Pa., March and 16, 1934. A third meeting will be held at Atlantic City, N. during the annual meeting of the Society.

The committee has been active in the development of new metho of testing insulating materials, in the improvement of the prese standard or tentative standard methods and in the drafting of spe fications. During the year a special committee with Mr. D. T. M as chairman was appointed to study the question of conditioni samples before test. The scope of the work is covered in detail the following recommendations affecting methods of test and in t description of the activities of the subcommittees.

Recommendations Affecting Standards

I. Proposed Tentative Standards:

Proposed Tentative Methods of Testing Molding Powders Used Manufacturing Molded Electrical Insulators.—Test methods for d termining particle size, apparent density and bulk factor of moldi powders used in manufacturing molded electrical insulation have bee prepared. These methods are intended to form the basis of specific tions for the purchase of such powders and have been prepared members of the committee who have actually used these tests in t purchase and sale of such powders. The committee according recommends that the proposed Tentative Methods of Testing Moldi Powders Used in Manufacturing Molded Electrical Insulators, a pended hereto,[1] be accepted for publication as tentative.

II. Proposed Tentative Revision of Standard:

Standard Methods of Testing Molded Materials Used for Electric Insulation (D 48 - 33).[2]—As indicated elsewhere in this report, it h been decided to make the Tentative Methods of Testing Sheet an Tape Insulating Materials for Dielectric Strength (D 149 - 33 T) reference method for dielectric strength tests to which other methods may refer for details. In accord with this purpose, the committee recommends the following revision of Methods D 48 – 33 for publication as tentative:[1]

---

[1] See p. 1001.—Ed.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 1097.

Sections 14 to 17, inclusive.—Replace this material, describing dielectric strength tests at commercial power frequencies, by the following Section 14, renumbering Sections 18 to 24, inclusive, accordingly:

DIELECTRIC STRENGTH

14. The dielectric strength shall be determined in accordance with the Tentative Methods of Testing Sheet, Tape and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 34 T) of the American Society for Testing Materials.

III. Adoption of Tentative Revision of Standard as Standard:

Standard Methods of Testing Electrical Porcelain (D 116 – 30).[2]—In the 1933 report of this committee, a tentative revision[3] of these methods was published which recommended the use of a short-time water absorption test as a measure of porosity for the more porous dry-process porcelain bodies. Tests for power factor, dielectric constant and resistivity were also added by reference to existing methods. The committee now recommends that this revision be advanced to standard and incorporated in the methods.

IV. Revision of Tentative Standards:

Tentative Methods of Testing Varnishes Used for Electrical Insulation (D 115 – 31 T).[4]—The committee is not ready to advance these methods to standard, and recommends that they be continued as tentative, with the following minor revision:

Section 3.—Renumber as Section 3 (*a*), and replace Note 1 which reads as follows:

> NOTE 1.—When measurements are made by an indirect method, the instrument used must be standardized. Oils of standard viscosity for use in standardizing such instruments can be obtained from the U. S. Bureau of Standards.

By the following new Paragraph (*b*), renumbering Note 2 accordingly:

---

[1] Additional tentative revisions of the Standard Methods D 48 were presented to Committee E-10 on Standards subsequent to the annual meeting, see Editorial Note, p. 510.—ED.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 1074.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 388 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 1086.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 848 (1931); also 1933 Book of A.S.T.M. Tentative Standards, p. 816.

(*b*) Viscosimeters used in this test shall be calibrated with oils certi as to viscosity in absolute units by the National Bureau of Standards. calibration curve having viscosities in absolute units as ordinates and instrum readings as abscissas and covering the range of viscosities to be measured, sl be used.

Tentative Methods of Testing Sheet and Tape Insulating Materi for Dielectric Strength (D 149 – 33 T).[1]—A decision to refer to Tentative Methods of Testing Sheet and Tape Insulating Materi for Thickness (D 374 – 33 T) for thickness measurements whene possible has necessitated certain changes in Methods D 149. Th are outlined below. As mentioned earlier in this report, it is intenc to use these as general reference methods for dielectric streng Changes have been proposed in the Standard Methods of Test Molded Materials Used in Electrical Insulation (D 48 – 33) to re to these methods. This change has necessitated certain edito modifications in Methods D 149 – 33 T and also revisions to specify electrodes to be used and procedure to be followed for testing molc materials. The committee accordingly recommends that these me ods be revised as follows and continued as tentative:

Section 1.—Add a new paragraph at the end of this section, follows:

> Tests on molded materials at room temperature shall be made in accordar with the special instructions covered under Dielectric Strength Tests on Molc Materials in Sections 34 to 38.

Section 3.—Rearrange and change to read as follows by the ad tion of the italicized words and figures:

> 3. The electrodes shall be of brass or copper with flat polished cont surfaces, *as follows:*
>
> (*a*) For sheet *and plate* materials [they] *the electrodes* shall be cylind 2 in. (50.8 mm.) in diameter and 1 in. (25.4 mm.) in length with the ed rounded to a radius of $\frac{1}{4}$ in. (6.35 mm.).
>
> (*b*) For tapes, the electrodes shall be cylindrical rods $\frac{1}{4}$ in. (6.35 mm.) diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.) and the up movable one shall weigh 0.1 lb. (45.4 g.) ± 0.005 lb. (2.3 g.).
>
> (*c*) *For molded materials the electrodes shall be cylinders 1 in. (25.4 m in diameter and 1 in. (25.4 mm.) in length with the edges rounded to a radius $\frac{1}{8}$ in. (3.18 mm.).*

Section 11.—Change from its present form: namely,

> 11. (*a*) The thickness shall be measured near the point of puncture w a machinist's micrometer graduated to 0.001 in. and having anvil and spin surfaces not less than 0.24 in. and not greater than 0.26 in. in diameter.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33; Part I, p. 828 (1933); also 1933 Book of A.S.T. Tentative Standards, p. 721.

> NOTE.—The micrometers specified in the Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness (A.S.T.M. Designation: D 374 – 33 T) of the American Society for Testing Materials are suitable for this purpose.

(*b*) The number of thickness readings on the specimen shall be equal to the number of punctures made under Section 10. In the case of tapes, the readings shall be distributed along the center line of the specimen in such manner as to represent closely the thickness at the points of puncture.

to read as follows:

11. (*a*) The number of thickness readings on the specimen shall be at least equal to the number of punctures made under Section 10.

> NOTE.—The micrometers and mode of operation specified in the Tentative Methods of Test for Thickness of Solid Electrical Insulation (A.S.T.M. Designation: D 374 – 34 T) of the American Society for Testing Materials are suitable for this purpose.

(*b*) In the cases of sheet material and molded material, the thickness shall be measured near the point of puncture.

(*c*) In the case of tapes, Method B of the Tentative Methods D 374 – 34 T shall be used. The readings shall be distributed along the center line of the specimen in such manner as to represent closely the thickness at the point of puncture. The average of these readings shall be the thickness used in calculating dielectric strength.

Section 12.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

12. Unless otherwise specified, the report shall include the following:
(*a*) The thickness of the specimen [at each puncture] *as determined in Section 11.*
(*b*) Total volts [and volts per mil of thickness] at each puncture.
(*c*) *Volts per mil of thickness for each puncture.*
(*d*) The average, maximum, and minimum volts [at puncture] per mil of thickness for each sample.
(*e*) The room temperature.
(*f*) The relative humidity, in per cent.
(*g*) The duration of the test.

Section 21.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

21. The thickness of the specimen shall be measured [at each puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.240 in. nor more than 0.260 in. in diameter] *in accordance with Section 11.*

Section 22.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

22. *Unless otherwise specified,* the report shall include the following:

(*a*) The thickness of the specimen [at each puncture] *as determined*
Section 11.

(*b*) Total volts [and volts per mil of thickness] at each puncture.

(*c*) *Volts per mil of thickness for each puncture.*

(*d*) The average, maximum, and minimum volts [at puncture] per mil
thickness for each sample.

(*e*) The room temperature.

(*f*) The relative humidity, in per cent.

(*g*) The duration of the test.

(*h*) The value of the initially applied voltage and the value of the volta
at each step.

Dielectric Strength Tests on Molded Materials.—Add the followi
as Sections 32 to 36, inclusive, to follow the present Section 3
renumbering the existing Sections 34 to 36 accordingly:

DIELECTRIC STRENGTH TESTS ON MOLDED MATERIALS

32. For testing molded materials the procedure described in Method
Short-Time Tests, Sections 3 to 12, and Method B, Step-by-Step Test, Sectio
13 to 21, shall be modified in accordance with Sections 35 to 38.

33. *Surrounding Medium.*—It is recommended that all tests on hot-mold
materials be made under oil and tests on cold-molded materials in air.

34. (*a*) *Test Specimen.*—The test specimen shall be molded in the fo
of a disk 4 in. (10.16 cm.) in diameter which shall be ⅛ in. (3.18 mm.) in thic
ness for hot-molded materials and ¼ in. (6.35 mm.) in thickness for cold-mold
materials.

> NOTE.—To permit the use of one mold for all molding compour
> the following variations in dimensions of the test specimen will be p
> missible:

For hot-molded compounds	± 5 per cent
For cold-molded compounds	± 10 per cent

(*b*) *Position of Electrodes.*—Tests shall be made between the standa
1-in. electrodes (Section 3 (*c*)) located at the center of the specimen.

35. *Number of Tests.*—For the Short-Time Method five tests shall
sufficient, and for the Step-by-Step Method three tests.

36. *Tests after Water Immersion.*—Three specimens shall be punctur
after they have had the rim immersed in melted paraffin for a depth of 1
(25.4 mm.) and have been entirely immersed in water for 48 hr. at norm
room temperature of about 20 C. (68 F.). The surface of the specimen shall
wiped off with a dry cloth to remove all trace of excessive surface moisture a
the puncture tests made immediately.

Section 36.—Renumber as Section 39 and change the first par
graph to read as follows by the addition of the italicized words:

39. The test material shall be subjected to the test temperature befo
voltage is applied, for a period in minutes equal to half the thickness of t
specimen in mils, *except molded materials, which shall be heated for 30 minut*

Appendix.—Add the following note to the second paragraph of the present appendix:

> NOTE.—Satisfactory washers 1-in. square or $1\frac{1}{8}$ in. in diameter have been made of sheet rubber about 0.10 in. in thickness. The "hardness" of the rubber was such that when 10 washers were stacked, a weight of 15 lb. compressed the stack about 10 per cent of its original height.

Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (D 150 - 32 T).[1]—During the past year a method of measuring power factor and dielectric constant at commercial frequencies has been developed. In using this method at 60 cycles on a wide range of materials it has been found that power factors are encountered of a much higher range (that is, up to possibly 0.8 or 0.9) than were encountered in measurements at higher frequencies. In such cases the definitions of dielectric constant and loss factor as now written require more specific and definite (even if arbitrary) definition. New definitions have been agreed upon. The committee accordingly recommends that these methods be revised as follows and continued as tentative:

Section 1.—Delete the present Note and add the following as Paragraph (*c*):

> (*c*) 25 to 60 cycles, the procedure being described in Sections 31 to 36, inclusive.

Section 3.—Change the dielectric constant definition to read as follows by the addition of the italicized words:

> 3. Dielectric Constant.—The dielectric constant of an insulating material is the ratio of the *equivalent parallel* capacitance (*see Fig. 3*) of a capacitor in which that material is the dielectric to the capacitance of a similar capacitor in which the dielectric is a vacuum. (For practical purposes air dielectric is equivalent to a vacuum.)

Section 4.—Change the loss factor definition by the addition of the italicized words and figures, the omission of the words in brackets and the addition of a note, as follows:

> 4. Loss Factor.—For the purpose of these methods the loss factor of an insulating material is the product of its [power factor and its] dielectric constant *and the cotangent of its phase angle* (θ, *Figs. 2 and 4*).
>
> NOTE.—When the cosine of the phase angle is less than 0.1, the cosine and cotangent are practically equal, and loss factor may be calculated from the following formula:
>
> Loss factor = Dielectric Constant, $K \times$ Power Factor

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 820 (1932); also 1933 Book of A.S.T.M. Tentative Standards, p. 778.

Section 7.—Change by the addition of the italicized words ar figures, the omission of the words in brackets and the addition of tv notes, as follows:

7. The [total] power loss per unit volume of insulating material for stated frequency, voltage gradient and temperature is proportional to t product of [the power factor and] *its* dielectric constant *and the cotangent of phase angle* (*θ, Figs. 2 and 4*). Therefore, the loss factor is defined as:

Loss Factor = [Power Factor ×] Dielectric Constant, K × *Cotangent of pha angle, θ*

NOTE 1.—Sine-wave voltage is assumed.

NOTE 2.—When the cosine of the phase angle is less than 0.1, t cosine and cotangent are practically equal, and loss factor may be ca culated from the following formula:

Loss Factor = Dielectric Constant, K × Power Factor

New Section.—Insert the following paragraph covering measur ments at other than room temperature as a new Section 11, renumberin the present Sections 11 to 29, accordingly:

11. *Measurements at Other than Room Temperature.*—It is frequent desirable to measure the losses in materials at temperatures other than roo temperature. In order to do this the apparatus for holding the specimen ma be placed within an oven for elevated temperatures and a refrigerator f lower temperatures. In either case the temperature shall be controlled accu rately. Proper care shall be exercised in carrying the leads from the bridg to the specimen so that they are properly insulated and shielded.

NOTE.—It is desirable to measure the humidity at all temperature Humidity may cause changes as large or larger than those caused b temperature.

New Test Procedure at 60 Cycles.—Add to the methods as Section 31 to 36, inclusive, the testing procedure to be followed in makin measurements at commercial power frequencies as shown appende hereto.[1]

Tentative Methods of Testing Compounds Used for Splicing Electric Cables and Filling Potheads (D 176 – 33 T).[2]—Last year Subcommit tee VI (M. F. Skinker, chairman) broadened the scope of its work t include all solid filling and treating compounds. These methods ca be applied to compounds in the broader scope, so the committe recommends that the methods be revised as follows and continued a tentative. Editorial changes throughout the method have bee made to conform to the change in scope.

---

[1] The new test procedure at 60 cycles has been incorporated in the revised Tentative Methods o Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (D 150 – 34 T see p. 1029.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 818 (1933); also 1933 Book of A.S.T.M Tentative Standards, p. 711.

Title.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> Tentative Methods of Testing *Solid Filling and Treating* Compounds Used for [Splicing] Electrical [Cables and Filling Potheads] *Insulation.*

Sections 5 and 12 (a).—To better describe the temperatures at which the compounds may be best poured to avoid air pockets, add the following sentence between the second and third sentences of Sections 5 and 12 (*a*):

> A melting and pouring temperature of approximately 50 C. above the softening point (ring-and-ball method) as determined under Section 2 (*b*) is recommended.

Coefficient of Expansion.—Considerable work on the measurement of coefficient of expansion of these materials proved that the results are greatly influenced by the expansion of entrapped gas in the compound. The present test method for coefficient of expansion using a glass flask has been rewritten to provide that the flask be filled under vacuum. A second method using a metallic measuring cell has been prepared. The design and use of this cell is such that easier and more definite filling is possible and the volume expansion of the material better obtained; this is especially true in the case of the asphalt and other opaque materials for which its use is prescribed. The committee accordingly recommends that the present method of measuring coefficient of expansion, Sections 16 to 22, inclusive, be deleted, and that the revised material with an appendix, as appended[1] to this report, be added to the methods as Sections 4 to 14, inclusive, and Appendix I respectively, renumbering the present Sections 4 to 15 and the present appendices to the methods accordingly.

Power Factor and Dielectric Constant.—A technique of preparing samples of these materials for the measurement of power factor and dielectric constant at various temperatures has been developed and its suitability verified by laboratory tests. The committee accordingly recommends that this technique and method which appears in Appendix II to this report be added to the methods as Sections 27 to 35, inclusive.

Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (D 202 - 33 T).[2]—For several years a method of testing paper for folding endurance has been under consideration. The machine originally devised at Massachusetts Institute of Technology has been carefully studied by the committee and the National Bureau of Standards and its essential details made the basis of the metho finally found suitable. The committee accordingly recommends th these methods be revised by the addition of the test method for foldi endurance, appended hereto,[1] as Sections 24 to 28, inclusive, renun bering the present Sections 24 to 53 accordingly, and the metho as revised continued as tentative.

---

[1] The revised coefficient of expansion method has been incorporated in the revised Tentative Methods of Testing Solid Filling and Treating Compounds Used for Electrical Insulation (D 176 - 34 T), see p. 965.—ED.

[2] *Proceedings,* Am. Soc. Testing Mats., Vol. 33, Part I, p. 839 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 757.

Tentative Methods of Testing Laminated Sheet Materials Used Electrical Insulation (D 229 – 32 T).[2]—These methods of test are al being used with satisfactory results for testing sheet and plate materia which are not laminated. In order to permit such use of the te methods, the committee recommends that the method be revised follows and continued as tentative:

Title.—Change to read as follows by the addition of the italicize words and the omission of the word in brackets:

> Tentative Methods of Testing [Laminated] Sheet *and Plate* Materia Used in Electrical Insulation.

Section 1.—Change to read as follows by the addition of t italicized words and the omission of the word in brackets:

> 1. These methods are intended to apply to [laminated] *stiff*, flat sheet *a* *plate* materials, *such as phenolic and other types of laminated sheets, vulcaniz fiber, hard rubber, asbestos composition board, etc.*, to be used as electric insulation.

Section 2.—Change the definitions of "flatwise" and "edgewise to read as follows by the addition of the italicized words and t omission of those in brackets:

> *Flatwise.*—Load applied to the [face] *flat side* of the [laminations] *origin sheet or plate.*
>
> *Edgewise.*—Load applied to the edge of the [laminations] *original sheet plate.*

Sections 34 to 39.—Since the test for bonding strength appli only to laminated materials, add the word laminated to the headin preceding these sections, thus making it read "For Laminate Materials $\frac{3}{16}$ in. or Over in Thickness."

Tentative Methods of Testing Varnished Cloths and Varnishe Cloth Tapes Used in Electrical Insulation (D 295 – 33 T).[3]—Stud during the past year has indicated that electrical test results o varnished cloth materials are seriously affected by humidity conditioning especially when the humidity is higher than 65 per cent relative humidity. Further study may lead to a recommendation of a definite humidity conditioning, but for the present, changes are proposed to call for this only when room humidities exceed 65 per cent relative humidity or when results are under question.

---

[1] The test method for folding endurance has been incorporated in the revised Tentative Metho of Testing Untreated Paper Used in Electrical Insulation (D 202 – 34 T), see p. 1007.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 860 (1932); also 1933 Book of A.S.T.M Tentative Standards, p. 738.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 864 (1933); also 1933 Book of A.S.T.M Tentative Standards, p. 805.

Direct reference to the Tentative Methods of Test for Thickness of Solid Electrical Insulation (D 374 - 34 T) is being provided for all thickness measurements in line with the policy of the committee to use Method D 374 in all of its standards where applicable.

Minor clarifying and simplifying changes are being made in the tests for dielectric strength and elongation. The test for resistance to oil is being quite considerably altered and amplified to make its details more definite.

The committee accordingly recommends the following changes for inclusion in these methods and their continuation as tentative:

Section 4.—Change from its present form: namely,

4. All specimens shall be taken from the samples selected in accordance with Section 3 and before testing shall be temperature conditioned for at least two hours in air maintained at a temperature between the limits of 20 and 30 C. (68 and 86 F.)

to read as follows:

4. (*a*) *Conditioning.*—The roll of cloth or tape from which specimens are to be cut shall be conditioned for a minimum of 2 hr. at a room temperature between the limits of 20 to 30 C., no humidity control.

(*b*) Specimens for tensile breaking strength, elongation, and dielectric strength "as received" shall be removed from the roll as required and tested immediately.

(*c*) If the room humidity is above 65 per cent, the roll of tape shall be kept in a cabinet whose relative humidity is maintained between 60 to 65 per cent.

(*d*) In the event of dispute, the test specimens shall be conditioned for 48 hr. at a temperature between 20 to 30 C. and at a relative humidity between 60 to 65 per cent.

Section 5.—Change this section from its present form to read as follows:

5. The thickness shall be measured in accordance with Method B of the Tentative Methods of Test for Thickness of Solid Electrical Insulation (A.S.T.M. Designation: D 374 - 34 T) of the American Society for Testing Materials.

Section 15.—Add the following paragraph to this section:

Dielectric strength tests may be applied to specimens of the material as received and on specimens from the elongation and resistance to oil tests.

Sections 20 to 24.—Delete the elongation test described in Se tions 20 and 21 and the test for resistance to oil described in Sectio 22 to 24 and replace by the revised testing procedures shown in th appendix to this report.[1] Renumber the remaining sections accordingl

Tentative Methods of Testing Laminated Tubes Used in Electric Insulation (*D 348 – 32 T*).[2]—The specimen for the water absorptio test has been specified to be the full section of the tube and 1 in. lon This is too large a specimen for large tubes. Also, the finish of th specimen should be more clearly defined. The committee accordingl recommends that these methods be revised as follows and continue as tentative:

Section 11.—Change from its present form: namely,

> 11. Specimens for the water absorption test shall be 1 in. in length. The shall be rinsed with gasoline to remove any oil from the machining operatio wiped with a dry cloth and allowed to stand in air for 2 hr. to remove the gasolin

to read as follows:

> 11. (*a*) Specimens of tubes having inside diameters less than 3 in. shall b the full section of the tube and 1 in. in length. For larger tubes, a rectangula specimen shall be cut 3 in. in length in the circumferential direction of th tube and 1 in. in width lengthwise of the tube.
>
> (*b*) The specimens shall be sawed from the sample so as to have smoot edges free from cracks. The cut edges shall be finished with No. 0 or fine sandpaper or emery cloth. Sawing and sandpapering operations shall be slo enough so that the material is not heated appreciably. The specimens sha be rinsed with gasoline to remove any oil from the machining operation, wipe with a dry cloth and allowed to stand in air for 2 hr. to remove the gasoline.

Tentative Methods of Testing Laminated Round Rods Used i Electrical Insulation (*D 349 – 32 T*).[3]—A water absorption test for rat of absorption has been developed, using the same procedure as fo plates. It was originally intended to proportion the dimensions o the specimens to have the same ratio of end areas to circumferentia area as the absorption through the circumference is not the same a through the ends, but this was not found to be practicable. Th committee accordingly recommends the water absorption test appended hereto,[4] be added to these methods as Sections 19 to 21, an that with this addition the methods be continued as tentative.

---

[1] The revised procedures for the elongation test and the test for resistance to oil have bee incorporated in the revised Tentative Methods of Testing Varnished Cloths and Varnished Clot Tapes Used in Electrical Insulation (D 295 – 34 T), see p. 1074.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 895 (1932); also 1933 Book of A.S.T.M Tentative Standards, p. 746.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 899 (1932); also 1933 Book of A.S.T.M Tentative Standards, p. 735.

[4] The water absorption test has been incorporated in the revised Tentative Methods of Testin Laminated Round Rods Used in Electrical Insulation (D 349 – 34 T), see p. 1051.—Ed.

Tentative Methods of Testing Sheet and Tape Electrical Insulation for Thickness (D 374 - 33 T).[1]—A year's use of this method has confirmed the advantage of having a separate test method for thickness measurements. The committee is taking steps to have all test methods under its jurisdiction refer to Method D 374 for thickness measurements if at all applicable. To this end the method has been revised to clarify and broaden its scope. A thorough-going rearrangement of the material, without essential change or omission, has added much to its clarity. The only essential change is the addition of a section which states the accuracy of the method to be of the order of 0.5 mil. The committee accordingly recommends that the method be revised as follows and continued as tentative:

Title.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> Tentative Methods of [Testing Sheet and Tape] *Test for Thickness of Solid* Electrical Insulation [for Thickness].

Section 1.—Renumber as Section 1 (*a*), and in the first sentence change the phrase "sheet and tape insulating materials" to read "solid insulating materials."

Add to this section the following as new Paragraphs (*b*) and (*c*):

> (*b*) Two alternative procedures, Methods *A* and *B*, are described. In Method A the use of an adjusted ratchet micrometer and a definite manipulative procedure controls the pressure exerted on the specimen. In Method B a micrometer without ratchet is used and pressure on the specimen is controlled by stopping closure of the micrometer when resistance to movement of the specimen between the instrument faces is first observed.
>
> (*c*) Method B is used generally for routine measurements. Method A, which may also be used for routine measurements, is preferable in cases of dispute. The precisions of the two methods are as follows:
>
> For unyielding materials, such as porcelain and laminated or molded phenolic materials, the maximum error of either method is of the order of 0.5 mil or less.
>
> For compressible materials, such as paper, fabric or leather, the maximum error of Method A is of the order of 0.5 mil. By applying the proper technique, Method B will give an accuracy of the order of 0.5 mil for the usual thicknesses of resilient materials encountered in the trade, except that for materials which are very compressible, the error may be somewhat greater.

Section 2.—Change the diameter of the anvil and spindle surfaces specified in the first sentences of Paragraphs (*a*) and (*b*) from "$\frac{1}{4}$ in." to read "0.250 in. ±0.001 in."

---

[1] ***Proceedings***, **Am. Soc. Testing Mats., Vol. 33, Part I, p. 860 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 801.**

Section 4.—Delete the first paragraph which reads as follows:

> Method A is suitable for determining the thickness of papers which n be held to very close tolerances. The instrument used shall conform to requirements specified in Section 2 (*a*).

Section 5.—Delete the first paragraph which reads as follows:

> Thickness measurements on papers, the acceptable tolerances of wl may be wider than those requiring the use of Method A, shall be made acc ing to Method B, as follows:

Tentative Specifications for Black Bias-Cut Varnished Cloth T Used for Electrical Insulation (*D 373 – 33 T*).[1]—Several minor clar ing changes in these specifications are proposed. It has been fou of advantage to classify these tapes into two classes, "greasy" a "tacky," according to their type of surface. The committee acco ingly recommends that these specifications be revised as follows a continued as tentative:

Section 1.—Add the following item to the Note under this secti

> Type of surface, greasy or tacky (Section 10)

New Section.—Add a new Section 10 as follows, renumbering present sections accordingly:

> 10. *Surface.*—Tapes are roughly divisible into two classes: "greasy" a "tacky." Greasy tapes shall have the property of sliding freely, one la upon another, when moved easily between two fingers.

Section 12.—Renumber as Section 13 (*a*) and change the fi sentence to read as follows by the addition of the italicized words:

> 13. *For tapes of nominal width not less than 0.5 in.* the elongation of c specimen from each of the selected rolls shall be measured at a temperature between 20 and 30 C. and shall be not less than that specified in the followi table:

Add the following as a new Paragraph (*b*):

> (*b*) The specimens tested for elongation shall be used for electrical te as described in Section 16.

Section 13.—Renumber as Section 14 (*a*) and add the followi as a new Paragraph (*b*):

> (*b*) The specimens tested for resistance to oil shall be used for electri tests as described in Section 17.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 809 (1933); also 1933 Book of A.S.T. Tentative Standards, p. 702.

Section 14 (a).—Renumber as Section 15 (*a*) and change the second sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

> The dielectric strength values are the [puncturing] ***puncture*** values in volts divided by the average [thickness (Section 7)] ***of the ten thickness readings on the specimen*** in mils.

Section 14 (b).—Change the first sentence to read as follows by the addition of the italicized words:

> The deviation factor for each roll ***in each shipment*** shall be not more than 0.11 when calculated from the following formula:

Section 14 (c).—Change the first sentence to read as follows by the addition of the italicized words:

> The deviation factor for *each roll in* each shipment shall be not more than 0.10 when calculated from the following formula:

The recommendations appearing in this report have been referred to letter ballot of the committee, which consists of 66 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Methods of Testing for Molding Powders Used in Manufacturing Molded Electrical Insulators	23	0	25
II. PROPOSED TENTATIVE REVISION OF STANDARD			
Methods of Testing Molded Materials Used for Electrical Insulation (D 48 - 33)	32	0	16
III. ADOPTION OF TENTATIVE REVISION OF STANDARD AS STANDARD			
Methods of Testing Electrical Porcelain (D 116 - 30)	23	0	25
IV. REVISION OF TENTATIVE STANDARDS			
Testing Varnishes Used for Electrical Insulation (D 115 - 31 T)	30	0	18
Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 - 33 T)	35	0	12
Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (D 150 - 32 T)	38	0	10
Testing Compounds Used for Splicing Electrical Cables and Filling Potheads (D 176 - 33 T)	31	1	15
Testing Untreated Paper Used in Electrical Insulation (D 202 - 33 T)	32	0	16
Testing Laminated Sheet Materials Used in Electrical Insulation (D 229 - 32 T)	31	0	17
Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 - 33 T)	32	2	14
Testing Laminated Tubes Used in Electrical Insulation (D 348 - 32 T)	26	1	16
Testing Laminated Round Rods Used in Electrical Insulation (D 349 - 32 T)	16	1	16
Testing Sheet and Tape Electrical Insulation for Thickness (D 374 - 33 T)	34	0	14
Specifications for Black Bias-Cut Varnished Cloth Tape Used for Electrical Insulation (D 373 - 33 T)	27	1	20

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Insulating Varnishes, Paints, and Lacquers (C. F. Hanson, chairman):

This subcommittee has continued its activities along the lines indicated in its report a year ago. Although considerable data have been accumulated toward the development of a test method for acid-

and alkali-resistance of varnish films, this study is held in abeyan for one year in order to focus attention on other problems which, f the present, appear to be more urgent. A development of a te method for hardness and oil resistance of varnish films is in progre and will continue to receive active consideration. The test for hea endurance of varnish films is being reviewed to determine wheth or not it is described with sufficient details.

Lacs and Synthetic Resins.—As reported a year ago a special se tion under the chairmanship of Mr. L. J. Cavanaugh, has been orga ized to carry on this work. For the present, this section is confini its efforts toward the selection and development of test methods f shellac used as an electrical insulating material. Through the c operation of the American Standards Association, this section compil a list of test methods for shellac showing the relationship of the various methods which are used by different associations througho the various nations. This compilation serves as an excellent bas for the coordination of this work.

Certain existing test methods have been selected by this secti and approved as being suitable for shellac used in electrical insulatio Work is in progress on checking experimentally existing test metho for flow and for polymerization with the view of either approvi these methods or modifying them in an attempt to obtain consiste and concordant results in various laboratories or to obtain simp fication.

Saturant Varnish.—The research project started on this wo over a year ago is still actively in progress. A new type of apparat has been designed and one instrument will be built according to th design for the purpose of studying particularly such properties of saturant varnish as impregnation, internal drying, bonding streng and dielectric strength when the varnish is used as an impregnati medium in cotton fabrics.

Subcommittee II on Molded Insulating Materials (A. M. Lynn, chai man):

Methods of Test for Molding Powders.—As mentioned earlier this report, Tentative Methods of Testing Molding Powders Used Manufacturing Molded Electrical Insulators which cover procedur for sampling, sieve analysis, apparent density and bulk factor ha been submitted for publication as a tentative standard as append hereto.[1] The future work of the subcommittee on this subject w be the development of methods of test for plasticity or flow and ra of cure for molding powders.

---

[1] See p. 1001.—Ed.

Standard Molds for Test Specimens.—A proposed design of standard mold for impact and flexural strength test specimens has been prepared and submitted to the subcommittee for consideration. The future work of the subcommittee on this subject will consist of the development of this standard test specimen mold and of similar standard molds for the tensile, compressive, and dielectric strength specimens shown in the Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 33).[1]

New Impact and Flexural Strength Specimens.[2]—The possibility of substituting a test specimen of $\frac{1}{8}$ by $\frac{1}{2}$-in. cross-sectional area for the present $\frac{1}{2}$ by $\frac{1}{2}$-in. cross-section specimen is being studied as it is believed that a much more uniform cure can be obtained on this thinner specimen. It is proposed to test this thinner specimen in groups of four to obtain breaking strengths of the same order as the present $\frac{1}{2}$ by $\frac{1}{2}$-in. specimen. The future work will consist of coöperative laboratory tests of the new specimen.

Dielectric Strength Tests.—As recommended earlier in the report, the dielectric strength test method for plastic molded insulating materials now given in Sections 14 to 17 of the Standard Methods of Testing Molded Insulating Materials Used for Electrical Insulation (D 48 – 33) will be replaced by the procedure described in the Standard Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 – 33 T). The future work of this section may consist of an investigation of the relative merits of a cup type specimen *versus* disk specimens for dielectric strength tests as there is some evidence that the results obtained are definitely affected by the type of test specimen used.

Conditioning of Test Specimens.—The work of this section, which has been recently organized, consists of a study of conditioning methods for plastic molded test specimens and the correlation of conditioning methods with other subcommittees.

Subcommittee III on Plates, Tubes and Rods (Dean Harvey, chairman):

Compressibility.—Further work on the 24-hr. test for compressibility has been discontinued until the question of the conditioning of test specimens has been decided, as the moisture content of the specimen has a large effect upon the compressibility.

---

[1] A proposed revision involving the use of specimens less than $\frac{1}{8}$ in. thick was accepted subsequent to the annual meeting as a tentative revision of these standard methods through Committee E–10 on Standards, see Editorial Note, p. 510.—ED.

[2] A revision of the Tentative Methods of Testing Electrical Insulating Materials for Resistance to Impact (D 256 – 33 T) was accepted subsequent to the annual meeting through Committee E–10 on Standards, see Editorial Note, p. 510.—ED.

An indentation hardness test using the Rockwell hardness teste is under consideration.[1]

Dielectric Strength.—A study to harmonize the methods of tes for dielectric strength of plates and tubes, molded materials an varnished cloth has been made jointly with Subcommittees II an VIII. A number of editorial changes have been made in the Tentativ Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 – 33 T) and it has been broadened to includ methods of test for laminated tubes and molded materials. Thes changes are referred to in detail earlier in the report.

Arc Resistance.—Data are being collected regarding the variou methods of test which are being used to determine arc resistanc They will be studied to decide upon a standard method of test.

Impact Testing.—Considerable impact testing has been done o both notched and unnotched specimens to develop a standard metho of test. It is proposed to test multiple thicknesses of specimens built up to a total thickness of ½ in., thus allowing plates less tha ½ in. thick to be tested. This method is being considered jointl with Subcommittee II.

Flammability.—Method of test for flammability has been prepared at the request of the National Electrical Manufacturers Association and is being tested in several laboratories.

Heat Endurance.—A method of test to determine deterioration i mechanical strength due to heat has been outlined, and preliminar tests have been made.

Thickness.—A new section has been organized to develop standard methods of gaging the thickness of plates, rods and tubes. It i desired to harmonize methods of gaging in line with the existin Tentative Methods of Testing Sheet and Tape Electrical Insulatio for Thickness (D 374 – 33 T).

Subcommittee IV on Insulating Mineral Oils (E. A. Snyder, chairman)

Neutralization Number.—The joint committee of members o Committee D-2 on Petroleum Products and Lubricants, and Committee D-9, referred to in the 1933 annual report,[2] has been carrying on the work of improving the present standard method for determining neutralization number and also developing an electrometri titration method. The initial high cost of the electrometric titration apparatus was one of the serious objections to this type of test and the work of the committee has been directed towards simplifying the apparatus and thus reducing its cost. Considerable progress has been made in this direction, and a sufficient number of laboratories have now equipped themselves with the apparatus so that the development of this phase of the work should proceed more rapidly during the coming year.

---

[1] The Rockwell hardness test was accepted subsequent to the annual meeting through Committe E-10 on Standards as a revision of the Tentative Methods of Testing Sheet and Plate Materials Use in Electrical Insulation (D 229 – 34 T), see Editorial Note, p. 510.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 400 (1933).

Sludge Test.—The work referred to in the 1933 annual report[1] was continued during the year, tests being made with the sludge accumulation test in the life test machine, both with and without copper catalyst present in the oil. Conclusions drawn from this year's work are as follows:

TESTS MADE IN THE ABSENCE OF COPPER

1. With tests made in the same laboratory, the amount of sludge formed appears to be checkable if the test in the absence of copper is run at 120 C. for a period extending at least as long as 42 days.

2. On the basis of the 1932–1933 tests without copper it is necessary to run the test at least as long as 42 days at 120 C. in order to draw any distinction between transformer oils of the type commercially available. For a poor grade of oil, an oxidation period as short as 21 days may serve to clearly differentiate the inferiority.

3. In order to minimize the variation in sludge test results due to uncontrollable factors in the oxidation itself, the test without copper should run at least as long as 35 days.

4. The average results of all laboratory tests made on the same oils during 1931–1932, as compared with similar results obtained during 1932–1933, show excellent agreement and indicate that with further improvement in the technique of this type of test (no copper), sufficient accuracy should be obtained to warrant its ultimate acceptance as a tentative procedure. Individual results at the present time probably are sufficiently at a variance to indicate that further work must be done before the no-copper test can be set up even as tentative.

TESTS MADE IN THE PRESENCE OF COPPER

1. From the data submitted by the one laboratory, the test at 120 C. with copper should be run over a period greater than 6 days in order to insure weighable amounts of sludge in the oil. Because of the possibility of inaccuracy in this type of test, resulting in some cases at least in wide variations in the check results run in the same laboratory, further work must be done before the copper-catalyzed sludge test can be considered as sufficiently reliable to warrant serious consideration as a tentative A.S.T.M. procedure.

2. The presence of copper tends to eliminate wide differences easily apparent when oils are sludged in the absence of copper.

3. If copper is used in the sludging test, indications are that the test must be extended at least as long as 6 days and preferably as long as 16 days before definite conclusions are drawn.

4. Judged on a percentage basis, the copper test does not appear to give any more erratic results than does the no-copper test. It must be remembered, however, that the sludge values obtained with the copper test are in most cases

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 400 (1933).

considerably higher than those obtained with the no-copper test, so that thi conclusion does not necessarily apply if consideration is given only to th absolute variation in results obtained.

The result of this year's work demonstrated the desirability o continuing work on the sludge accumulation test with a coppe catalyst present. Efforts will be directed towards eliminating cause for discrepancies in actual test values between laboratories and t work out the details of the technique of this type of test so as t enable the subcommittee to write it up in the form of a tentativ standard. The advantage of a copper catalyst in reducing the tim required for the test to approximately one-sixth the time required t run it without a copper catalyst is obvious. Furthermore, ther is a possibility that oils may react differently to oxidation condition in the presence of a catalyst than they do in the absence of a catalyst The main part of the work of the subcommittee during the comin year will be centered on this phase of the test and in further improvement of the technique of the test without the copper catalyst.

Short-Time Sludge Test.—The aluminum block oven for use i the sligh test, referred to in the 1933 annual report, has been furthe modified and improved and is now obtainable from the Fisher Scientific Co. The section on this work is cooperating with Subcommitte X on Sligh Oxidation Test, of Committee D-2, and the presentatio of a tentative standard is being withheld until such time as Committee D-2 and Committee D-9 can come to a definite agreement o a procedure of operation.

Saponification Number.—The section studying the saponificatio test for new and used insulating oils has come to the conclusion tha the Baader saponification test is superior to the standard A.S.T.M procedure. A modified Baader method which is being considered by this section is published as information in the Appendix to this report

Moisture in Insulating Oils.—The section working on this subjec is devoting its time to developing a test that is more sensitive than a dielectric test for determining the presence of moisture and also one that will give quantitative measurements of minute amounts. Ther seems to be an increasing demand for this type of test from manufacturers of electrical equipment.

Cable Oils.—There has been an increasing demand during th past year for the development of special tests applicable to cable oils A section has been appointed by the subcommittee to go over all th suggestions received and determine, first, whether it would be advisable for the subcommittee to undertake the work; and second, i so, what tests to consider for development and standardization a present. It seems fairly definite that this work will be started during the coming year, and the subcommittee would be glad to have further comments from users and manufacturers of cables and cable oils on both the question as to types of tests to consider, and the advisability of developing and standardizing them.

Subcommittee VI on Solid Filling and Treating Compounds (M. F. Skinker, chairman):

To agree with the new title of this subcommittee, the title of the Tentative Methods D 176 has been changed to "Tentative Methods of Testing Solid Filling and Treating Compounds Used for Electrical Insulation." A new method for measuring the coefficient of expansion using a metallic cell and methods for measuring the power factor and dielectric constant of these materials have been added to the tentative methods. These changes are covered in detail earlier in the report. Work is being continued on measuring effective coefficient of expansion of these materials as received and the development of test cells for compounds which have a large coefficient of expansion.

Subcommittee VII on Electrical Tests (E. S. Lee, chairman):

The completed work for the year has resulted in the revision of the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (D 150 – 32 T) to include measurement of power factor at frequencies in the order of 60 cycles to cover the frequency range. This additional procedure is referred to earlier in the report.

In the interest of the work of the subcommittee the following paper is being presented before the Society at this annual meeting: "A Comparison of the Methods for Testing Insulating Materials for Power Factor and Dielectric Constant at 1000 Cycles," by W. B. Kouwenhoven and L. W. Marks.[1] Another paper of interest was published in the *General Electric Review* for May, 1934, entitled, "Amplifiers for Alternating Current Bridges," by H. W. Bousman and W. A. Ford.

Future work includes development of test cells for oil specimens for measurement of power factor, development of method for measuring power factor of mica, development of new method for electrical tests of slate, and coordination of all Society methods for the determination of dielectric strength to accomplish simplification and improvement of testing technique.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part II, p. 821 (1934).

Subcommittee VIII on Insulating Papers and Fabrics (*Treated an* *Untreated*) (R. W. Chadbourne, chairman):

During the past year, Subcommittee VIII has developed method for determining the folding endurance of papers to be include in the Tentative Methods of Testing Untreated Paper Used in Ele trical Insulation (D 202 – 33 T). The Tentative Methods of Tes ing Sheet and Tape Electrical Insulation for Thickness (D 374 – 33 T have been revised and expanded to include test procedures for othe materials, as well as statements on the applications and precision of the two methods therein described. As the result of a study of th effect of humidity on the dielectric strength of varnished cambri tape, a new conditioning procedure has been recommended for in clusion in Tentative Methods of Testing Varnished Cloths an Varnished Cloth Tapes Used in Electrical Insulation (D 295 – 33 T) Several other minor changes have been recommended in this latte method, and also in Tentative Methods of Testing Sheet and Tap Insulating Materials for Dielectric Strength (D 149 – 33 T), an Tentative Specifications for Black Bias-Cut Varnished Cloth Tap Used for Electrical Insulation (D 373 – 33 T). These changes ar given in detail earlier in this report.

Untreated Paper.—A series of tests is now being arranged to de termine whether or not the electrometric method is superior to th colorimetric method for the determination of acidity in insulatin papers.[1]

An attempt is being made to secure closer cooperation with th Technical Association of the Pulp and Paper Industry. Officia representation on Committee D-9 has been given to T.A.P.P.I. and a proposal for joint sections, comprising representatives of bot societies, for consideration and development of standards, is bein submitted to the Paper Testing Committee of T.A.P.P.I. It is hope that through these moves, present differences in standard method may be eliminated and future differences avoided.

Since the adoption last year of a separate standard on thicknes measurements, an attempt has been made to expand the application of this method and thereby reduce the number of methods of deter mining thickness of various insulating materials. This work is bein done with the cooperation of the Section on Thickness.

Treated Fabrics.—The effect of humidity on the dielectric strengt of varnished cambric is receiving considerable attention. A stand ard involving humidities of less than 65 per cent has been devised the relation of higher humidities to dielectric strength is now being studied. The effects of various temperatures over the entire range of use will also be shortly investigated.

---

[1] A minor improvement of the test for acidity and alkalinity of insulating papers was accepted sub sequent to the annual meeting through Committee E-10 on Standards, see Editorial Note, p. 510.—Ed

A new section has been created to consider problems, such as conditioning, etc., relating to varnished tubing.

Subcommittee IX on Mica Products (M. P. Davis, chairman).—Data is being collected on the preparation of tentative purchase specifications for mica and mica products, such as bonded mica. Comments have been received in regard to the published Tentative Methods of Test for Grading Natural Mica According to Size, Commercial Quality and Thickness (D 351 – 33 T) and Tentative Methods of Testing Pasted Mica Used in Electrical Insulation (D 352 – 32 T), and laboratory tests are being conducted on suggested changes and improvements.

The election of officers resulted in the selection of T. S. Taylor, chairman, Dean Harvey, vice-chairman, and E. J. Rutan, secretary, for the ensuing term of two years.

This report has been submitted to letter ballot of the committee, which consists of 66 members; 48 members returned their ballots, of whom 46 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

H. L. CURTIS,
Chairman.

J. A. SCOTT,
Secretary.

EDITORIAL NOTE

The proposed Tentative Methods of Testing Molding Powders Used in Manufacturing Molded Electrical Insulators were accepted for publication as tentative and appear on page 1001.

The proposed tentative revision of the Standard Methods of Testing Molded Materials Used for Electrical Insulation was accepted for publication as tentative and appears on page 488.

The tentative revision of the Standard Methods of Testing Electrical Porcelain was approved for reference to letter ballot of the Society for adoption as standard. The methods in their revised form appear in the 1934 Supplement to Book of A.S.T.M. Standards, page 170.

The proposed revisions of the Tentative Methods of Testing Varnishes Used for Electrical Insulation, Testing Sheet and Tape Insulating Materials for Dielectric Strength, Testing Electrical Insulating Materials for Power Factor and Dielectric Constant, Testing Compounds Used for Splicing Electrical Cables and Filling Potheads, Testing Untreated Paper Used in Electrical Insulation, Testing Laminated Sheet Materials Used in Electrical Insulation, Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical I sulation, Testing Laminated Tubes Used in Electrical Insulation, Testi Laminated Round Rods Used in Electrical Insulation, Testing Sheet and Ta Electrical Insulation for Thickness and Specifications for Black Bias-Cut Va nished Cloth Tape Used for Electrical Insulation were accepted. The metho and specifications in their revised forms appear on pages 965 to 1100, inclusiv

Recommendations to Committee E-10 on Standards.—Additional revisions the Tentative Methods of Testing Untreated Paper Used in Electrical Insul tion and of the Tentative Methods of Testing Laminated Sheet Materials Us in Electrical Insulation were approved by the committee subsequent to t annual meeting and accepted on August 22, 1934, by Committee E-10 Standards. The methods in their revised form appear on pages 1007 and 105 respectively.

A revision of the Tentative Methods of Testing Electrical Insulati Materials for Resistance to Impact was also presented to Committee E-10 ar accepted on August 22, 1934. The methods in their revised form appear page 995.

An additional proposed revision of the Standard Methods of Testing Mold Materials Used for Electrical Insulation was also presented to Committee E- and accepted for publication as a tentative revision on August 22, 1934. Tl revision appears on page 1277.

APPENDIX

MODIFIED BAADER SAPONIFICATION TEST FOR ELECTRICAL INSULATING OILS[1]

1. *Scope.*—This modified Baader saponification test is intended for the determination of the saponification number of electrical insulating oils.

APPARATUS

2. (*a*) *Erlenmeyer Flask.*—An Erlenmeyer flask of 250-ml. capacity fitted with a ground-glass joint to a reliable reflux condenser. The Erlenmeyer flask should be made of Jena G-20 glass.

(*b*) *Hot Plate.*—A suitable hot plate.

SOLUTIONS REQUIRED

3. The following solutions will be required:

(*a*) *Alcoholic Solution for Saponification.*—Dissolve about 6 g. of potassium hydroxide (purified by alcohol) in 500 ml. of 95 per cent purified ethyl alcohol. Allow the solution to settle in a dark place. Draw off the clear solution or filter through an asbestos filter and make up to 1 liter with 95 per cent alcohol. The solution so prepared shall then be allowed to stand at least 20 hr. before it is standardized.

(*b*) *Alcohol.*—Purify 95 per cent ethyl alcohol with silver oxide in the following manner: Dissolve 1.5 g. of silver nitrate c.p. in about 3 ml. of water and add to 1 liter of alcohol in a glass-stoppered bottle, and mix thoroughly. Dissolve 3 g. of potassium hydroxide (purified by alcohol), in 10 to 15 ml. of warm alcohol. After cooling, add slowly to the alcoholic silver nitrate solution, stirring slightly. Allow the precipitated silver oxide to settle, siphon off the clear solution and distill on a steam bath.

(*c*) *Standard Hydrochloric Acid Solution.*—0.1 *N* solution.

(*d*) *Alkali Blue Solution.*—Dissolve 0.6 g. of alkali blue *6-B* in 1500 ml. of 95 per cent alcohol and 1000 ml. of pure benzene.

PROCEDURE

4. (*a*) *Blank Determination.*—Determinations shall be made in duplicate with the alcoholic potassium hydroxide solution in the following manner: Measure accurately into the flask 25 ml. of alcoholic potassium hydroxide solution from a standard burette, allowing 60 sec. total time for drawing and draining. Add 75 ml. of the alkali blue solution to the alcoholic potassium hydroxide in the flask, connect the flask to the reflux condenser and boil for 30 min. Titrate while hot with 0.1 *N* HCl.

(*b*) *Test Procedure.*—Weigh 5 to 8 g. of the oil accurately, by difference, from a small beaker into the saponification flask. Add 25 ml. of alcoholic potassium hydroxide solution and 75 ml. of the alkali blue solution in the same manner as for the blank, connect the flask to the reflux condenser and boil for 30 min. Titrate while hot with 0.1 *N* HCl.

---

[1] This method, evolved as the best from many studied and tried by Committee D-9 and considered by it to be superior to the present standard method for testing insulating oils (both new and used), is published for information and criticism prior to submitting it to the Society as tentative. Criticism is solicited and should be directed to E. J. Rutan, Secretary of Committee D-9 on Electrical Insulating Materials, The New York Edison Co., 92 Vandam St., New York City.

(*c*) Titrations should be carried out as quickly and with as little splashin as possible, because the alkali blue solution is sensitive to carbon dioxide an air contamination. Any change after the first end point is ignored.

5. *Calculation.*—Calculate the saponification number from the differenc between the number of milliliters of 0.1 N HCl required for the determinatio and the average of the two blanks, using the following formula:

$$\text{Saponification number} = \frac{\text{Difference, milliliters} \times 5.611}{\text{Weight of oil in grams}}$$

ACCURACY

6. *Accuracy.*—With proper precautions observed, duplicate determina tions by the same operator should agree within 0.1 saponification numbe For different operators the tolerance may be double this amount.

REPORT OF COMMITTEE D-11
ON
RUBBER PRODUCTS

Committee D-11 on Rubber Products has held one meeting during the year in addition to the one held during the 1933 annual meeting. This was at Washington, D. C., on March 6, 1934, in connection with the Spring Group Meetings of A.S.T.M. Committees. No fall meeting of the committee was held because of the generally adverse business conditions during 1933, and because the work of the committee was progressing in a satisfactory manner.

Representation of Committee D-11 on other committees of the Society has been provided by the following appointments:

Mr. C. S. Reeve on Committee D-15 on Thermometers and Laboratory Glassware;

Mr. G. S. Haslam on the Technical Committee on Size and Shape, of Committee E-1 on Methods of Testing;

Mr. P. L. Wormeley on the Technical Committee on Thickness Measurements, of Committee E-1;

Mr. E. D. Youmans has been designated, on the recommendation of Committee D-11, as one of the A.S.T.M. representatives on Sectional Committee C59 on Electrical Insulating Materials, functioning under the procedure of the American Standards Association with the Society as sponsor.

Subsequent to the 1933 annual meeting, the committee presented to the Society through Committee E-10 on Standards the following three new tentative methods of test and revisions of two existing tentative specifications:

New Tentative Methods of:
- Testing Rubber Belting Used for Power Transmission (D 378 – 33 T)
- Test for Rubber Hose—Braided Construction (D 379 – 33 T)
- Test for Rubber Hose—Wrapped Construction (D 380 – 33 T)

Revised Tentative Specifications for:
- Insulated Wire and Cable: 30 per cent Hevea Rubber (D 27 – 33 T)
- Insulated Wire and Cable: Performance Rubber Compound (D 353 – 33 T)

Details of these recommendations were discussed in last year's annual report of the committee.[1] The new and revised tentative standards were accepted for publication as tentative by Committ E-10 at a meeting held on August 16, 1933,[1] and appear in the 19 *Proceedings.*[2]

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 406 (1933).

RECOMMENDATIONS AFFECTING STANDARDS

I. Proposed Tentative Standards:

Proposed Tentative Methods of Test for Abrasion Resistance Rubber Compounds.—Committee D-11 in the past has devoted a lar amount of study to the question of measuring the resistance of rubb products to abrasive wear. No single test has ever been develop which is entirely satisfactory for this purpose under all conditio On the other hand, a large number of different tests have been devis in various laboratories, some of which have been of great value connection with development work and in special applicatio Equipment for the six most widely used methods is commercial available. The committee is not in a position to recommend a one of the six for exclusive use but recognizes that all six metho provide valuable technical information under certain conditions. is felt, however, that standardization in this field of testing is bad needed and that a substantial part of the test procedure is comm to all of the methods. The committee also believes that the p cedure for conducting a test on each of the six available machi should be standardized even though it is not desirable to single o a particular machine for recommendation. Accordingly, a propos composite method has been prepared in which standardization carried so far as is practicable at the present time. In submitti the method, the committee implies in effect that it is unwilling recommend any one of the most commonly used test machines to t exclusion of the others but that if any one is used, the test should carried out in the standard way as prescribed. It is believed th there is great need for this kind of standardization in this particul case and that great benefit will result from it by making results fro different laboratories more comparable and by stimulating improv ment of testing procedures for measuring resistance to abrasion. T committee accordingly recommends that the proposed Tentative Methods of Test for Abrasion Resistance of Rubber Compounds, appended hereto,[1] be accepted for publication as tentative.[2]

---

[1] In submitting these recommendations to Committee E-10 on Standards, the committee repor the following results of the letter ballot vote of a total of 36 ballots returned from a committee memb ship of 75: Tentative Methods of Testing Rubber Belting Used for Power Transmission (D 378 – 33 20 affirmative and none negative; Tentative Methods of Test for Rubber Hose—Braided Construct (D 379 – 33 T), 22 affirmative and none negative; Tentative Methods of Test for Rubber Hos Wrapped Construction (D 380 – 33 T), 22 affirmative and none negative; Tentative Specifications Insulated Wire and Cable: 30 per cent Hevea Rubber (D 27 – 33 T), 28 affirmative and none negati Tentative Specifications for Insulated Wire and Cable: Performance Rubber Compound (D 35 33 T), 28 affirmative and none negative.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 871 to 920 (1933); also 1933 Book A.S.T.M. Tentative Standards, pp. 897, 905, 911, 854 and 877.

Proposed Tentative Method of Test for Compression Set of Vulcanized Rubber.—In the 1933 annual report[3] a proposed method of test for compression set of rubber used for vibration absorption was discussed. It was intended at that time to submit this method to the Society for publication as tentative through Committee E-10 on Standards. Due to the development of objections to the method, however, it was withheld for further study in the subcommittee. Some revisions have been made, and Committee D-11 believes that the method is now suitable for publication as tentative. While it is not contemplated that the method in its present form will be entirely satisfactory in all cases, because in this particular test field opinions vary widely, nevertheless, the committee believes that the proposed method represents the best practice at present available and will provide a desirable reference test for standardization and arbitration purposes. The committee accordingly recommends that the proposed Tentative Method of Test for Compression Set of Vulcanized Rubber, appended hereto,[4] be accepted for publication as tentative.

Proposed Tentative Specifications for Insulated Wire and Cable: Class A, 30 per cent Hevea Rubber Compound.—These specifications include material which formerly appeared in the Tentative Specifications for Insulated Wire and Cable: 30 per cent Hevea Rubber (D 27 – 33 T). The latter specifications have heretofore covered the use of two different types of rubber compounds, designated Class A and Class AO, the latter of which permits the use of organic accelerators and antioxidants. In practice, Class AO compound has largely superseded the Class A compound although there is still a definite demand for the Class A compound which will probably continue. In Specifications D 27 – 33 T, Class A compound occupies a rather preferred position which is somewhat misleading. The committee believes that it will be preferable to separate the insulated wire specifications according to the type of insulating compound used. It is, therefore, proposed to provide three individual standards of which this recommendation, covering Class A compound only, will be one. The Tentative Specifications for Insulated Wire and Cable: 30 per cent

---

[1] See p. 1150.—ED.

[2] A revision of these tentative methods was presented to Committee E-10 on Standards subsequent to the annual meeting, see Editorial Note, p. 521.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 409 (1933).

[4] See p. 1164.—ED.

Hevea Rubber (D 27 – 33 T) will be revised to cover only the Cla
AO compound, and the Tentative Specifications for Insulated Wi
and Cable: Performance Rubber Compound (D 353 – 33 T) will co
tinue as at present. The committee accordingly recommends th
the proposed Tentative Specifications for Insulated Wire and Cabl
Class A, 30 per cent Hevea Rubber Compound, appended hereto
be accepted for publication as tentative.

II. Revisions of Tentative Standards:

*Tentative Specifications for Insulated Wire and Cable: 30 p
cent Hevea Rubber (D 27 – 33 T).*[2]—To bring these specifications
accord with the program described above, certain modifications
the specifications are necessary to accomplish the separation of th
two classes of rubber compound. In addition, a new section on shiel
ing is to be incorporated and test procedures for moisture absorptio
and tensile stress, used in the performance compound specificatio
(D 353 – 33 T),[3] are to be added as well as other desirable chang
made, all of which contribute greatly to improvement of the spec
fications in line with best modern practice. The committee accor
ingly recommends that Tentative Specifications D 27 – 33 T in the
revised form, as appended hereto,[4] be accepted for publication
tentative.[5]

*Tentative Specifications for Friction Tape for General Use f
Electrical Purposes (D 69 – 32 T).*[6]—In response to a demand at th
last annual meeting, which was quite general on the part of bot
consumers and producers, these specifications have been carefull
studied during the past year with a view toward making them a
suitable as possible to cover quality tapes as produced at presen
The changes proposed are quite detailed but special attention is calle
to the inclusion of requirements for maximum length per roll, a ne
test for tackiness, and revisions in the method of sampling. Thes
changes are considered to represent distinct improvement in thes
specifications. As a result of this work, the committee recommend
that Tentative Specifications D 69 in their revised form, as appende
hereto,[7] be accepted for publication as tentative.

---

[1] See p. 1126.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 871 (1933); also 1933 Book of A.S.T.M
Tentative Standards, p. 854.

[3] A revision of the Tentative Specifications D 353 was presented to Committee E-10 on Standard
subsequent to the annual meeting, see Editorial Note, p. 521.—ED.

[4] See p. 1101.—ED.

[5] Additional revisions of the Tentative Specifications D 27 were presented to Committee E-10 o
Standards subsequent to the annual meeting; see Editorial Note, p. 521.—ED.

[6] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 926 (1932); also 1933 Book of A.S.T.M
Tentative Standards, p. 889.

[7] See p. 1139.—ED.

III. Adoption of Tentative Standards as Standard:

Committee D-11 recommends that the following tentative standards be approved for submission to letter ballot of the Society for adoption as standard without revision:

Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public and Private Fire Department Use (D 296 – 31 T)[1]

Tentative Method of Test for Hardness of Rubber (D 314 – 31 T)[1]

These tentative standards have had a tentative status for three years and no serious criticisms nor unfavorable comments have been received concerning them. The specifications for fire hose enjoy wide acceptance and have been approved as American Tentative Standard by the American Standards Association. In the case of the method of test for hardness of rubber, there is a definite need for a different method than this, employing a smaller, more portable test device having equivalent accuracy which would be more convenient for inspection purposes; however, the present method seems quite satisfactory as a reference standard and is itself in fairly extensive industrial use. The committee has decided to investigate the possibility of using this method for the purposes of the Tentative Specifications for Rubber Pump Valves (D 151 – 31 T) in place of the hardness test now required. It is therefore desired that these specifications be continued as tentative.

IV. Publication as Information of Proposed Specifications:

Proposed Specifications for Rubber Insulating Blankets for Use Around Electrical Apparatus or Circuits Not Exceeding 3000 Volts to Ground.—The committee is submitting these specifications for publication for information only. The specifications were prepared in response to several requests but progress in their standardization has been slow due to limited representation of interested parties on the committee. As with other devices designed to protect human life, there is a definite need for these specifications in a limited but very important field. In order to make available additional comment to that which can be secured in the committee, the specifications appearing in Appendix I are published at this time for information only; under this plan of publication the specifications have no official status within the Society.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 76 members, with the following results:

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 903, 971 (1931); also 1933 Book of A.S.T.M. Tentative Standards, pp. 836, 902.

Items	Affirm-ative	Neg-ative
I. PROPOSED TENTATIVE STANDARDS		
Methods of Test for Abrasion Resistance of Rubber Compounds	30	0
Method of Test for Compression Set of Vulcanized Rubber[a]	24	3
Specifications for Insulated Wire and Cable: Class A, 30 per cent Hevea Rubber Compound	29	1
II. REVISIONS OF TENTATIVE STANDARDS		
Specifications for Insulated Wire and Cable: 30 per cent Hevea Rubber (D 27 - 33 T)	26	1
Specifications for Friction Tape for General Use for Electrical Purposes (D 69 - 32 T)	26	1
III. ADOPTION OF TENTATIVE STANDARDS AS STANDARD		
Specifications for Cotton Rubber-Lined Fire Hose for Public and Private Fire Department Use (D 296 - 31 T)	25	0
Method of Test for Hardness of Rubber (D 314 - 31 T)	31	2
IV. PUBLICATION AS INFORMATION OF PROPOSED SPECIFICATIONS		
Proposed Specifications for Rubber Insulating Blankets for Use Around Electrical Apparatus or Circuits Not Exceeding 3000 Volts to Ground	25	0

[a] The classified vote on the Tentative Method of Test for Compression Set of Vulcanized R was as follows: Affirmative: 8 producers, 8 consumers, 8 general interests; negative: 2 prod 1 consumer, 0 general interests; not voting: 6 producers, 3 consumers, 4 general interests.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee IX on Insulating Tape has been reorganize authorized at the meeting of the committee last June and is under chairmanship of Mr. M. F. Skinker. Mr. Harry Frecker, Jr., replaced Mr. Arthur W. Carpenter as chairman of Subcommitte on Physical Testing. Mr. J. J. Allen has been appointed chairma Subcommittee XVII on Rubber Products for Absorbing Vibrat replacing Mr. F. D. Abbott. Mr. A. H. Flower has replaced Allen as chairman of Subcommittee XX on Adhesion Tests.

Subcommittee IV on Protection of Persons from Electric S (H. S. Vassar, chairman).—This subcommittee is submitting for p lication as information the proposed Specifications for Rubber Insu ing Blankets for Use Around Electrical Apparatus or Circuits Not ceeding 3000 Volts to Ground, referred to earlier in this report which appear in Appendix I. Included in these specifications is a non-destructive test which has been discussed in the subcommittee. C siderable attention has been given by the subcommittee to the deve ment of such tests, which are extremely desirable for use with produ sold in small quantities where the destruction of a single article test purposes represents a substantial proportional loss. This ph of testing is particularly important with articles where a human hazard is involved since 100 per cent testing is desirable, and t which destroy or injure the serviceability of the product are obviou out of the question.

Subcommittee V on Insulated Wire and Cable (C. B. Martin, ch man).—This subcommittee has as usual been very active through the year and is sponsoring at this time several changes in exist specifications for insulated wire and cable, as mentioned earlie this report. In addition, the work of the several sections is proceeding along lines outlined in the 1933 annual report.[1] A new Section 4 has been organized under the chairmanship of Mr. R. A. Schatzel to undertake the preparation of specifications for a 60 per cent rubber sheath compound. Section 1 has had the added duty assigned to it of preparing a table of standards for rubber insulation thicknesses for circuits of 8000 volts to the highest voltage in commercial use, to apply to insulation especially designed for such high voltage service. The subcommittee also proposes to devise a plan whereby the Geer oven, oxygen bomb and moisture absorption requirements of the specifications covering insulated wire may be reported and certified by the manufacturers in lieu of actual purchasers' acceptance tests.

Subcommittee IX on Insulating Tape (M. F. Skinker, chairman).—During the early part of the year considerable attention was given to reorganization of this subcommittee, which has since been exceedingly active and has held several *ad interim* meetings. The results of this work are presented in the revisions of the Tentative Specifications for Friction Tape for General Use for Electrical Purposes (D 69 – 32 T), mentioned earlier in this report and which have been incorporated in the revised specifications appended hereto.[2] Substantial progress is also being made toward revisions of the Tentative Specifications for Rubber Insulating Tape (D 119 – 32 T).[3]

Subcommittee X on Physical Testing of Rubber Products (Harry Frecker, Jr., chairman).—This subcommittee is proceeding with the plans for the preparation of a pamphlet on Methods of Test for Rubber Products. The subcommittee is actively cooperating with the other subcommittees of Committee D-11 in the preparation of new tentative standards which will be suitable for inclusion in the pamphlet, and is preparing an outline for the completed work.

Subcommittee XIV on Abrasion Tests for Rubber Products (G. S. Haslam, chairman).—The subcommittee has devoted its attention during the year to the preparation of the proposed Tentative Methods of Test for Abrasion Resistance of Rubber Compounds which are recommended for publication as tentative, as appended hereto,[4] as mentioned earlier in this report.

Subcommittee XV on Life Tests for Rubber Products (R. A. Schatzel, chairman).—This subcommittee is working on the preparation of methods of testing accelerated age deterioration of rubber and expects to recommend them for publication as tentative in the near future.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 408 (1933).

[2] See p. 1139.—Ed.

[3] A revision of the Tentative Specifications D 119 was presented to Committee E-10 on Standards subsequent to the annual meeting, see Editorial Note, p. 521.—Ed.

[4] See p. 1150.—Ed.

Subcommittee XVII on Rubber Products for Absorbing Vibrat (J. J. Allen, chairman).—This subcommittee is submitting for pul cation as tentative the proposed Tentative Method of Test for Co pression Set of Vulcanized Rubber, appended hereto,[1] and is reco mending the adoption as standard of the Tentative Method of T for Hardness of Rubber (D 314 – 31 T). Further work is conte plated on the compression set test, directed particularly to the devel ment of better methods for measuring the final thicknesses of tested samples. The subcommittee is also investigating the gene subject of compression testing and is preparing a questionnaire cov ing present methods by means of which it is hoped to secure a valua survey of this field. The subcommittee has decided that it is i practical because of instrument and laboratory variations to try establish a definite correlated relationship between the various har ness tests of rubber, such as those using the A.S.T.M. standard strument, the Pusey and Jones plastometer, and the Shore duromet It is considered preferable for each laboratory to have its own struments checked against the A.S.T.M. reference standard.

Subcommittee XIX on Tests for Properties of Rubber and Rubb Like Materials in Liquids (O. M. Hayden, chairman).—The orga zation of this subcommittee has been completed and its work active begun. An extensive questionnaire has been prepared and mail to 150 laboratories in order to provide a cross-section idea of the te now in use, which will furnish a basis for the future work of the su committee. A technical paper on "The Testing of Rubber a Rubber-Like Material for Oil Resistance" by the chairman of t subcommittee is being presented at this annual meeting.[2]

Subcommittee XX on Adhesion Tests (A. H. Flower, chairman). Organization of this subcommittee has been completed and wo actively started looking toward the development of methods for te ing adhesion. Attention is being given particularly to the measu ment of adhesion between rubber and metal in automotive par A test procedure and apparatus that has been developed by t chairman is described in the paper by A. H. Flower and H. E. Weni entitled "Proposed Method for Testing the Adhesion of Rubber Metal" which appears in Appendix II.

The election of officers for the ensuing term of two years result in the selection of H. A. Depew, chairman; C. H. Zieme, vice-chai man; and Arthur W. Carpenter, secretary.

---

[1] See p. 1164.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part II, p. 635 (1934).

This report has been submitted to letter ballot of the committee which consists of 76 members; 40 members returned their ballots, of whom 35 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

ARTHUR W. CARPENTER, *Secretary.*
H. A. DEPEW, *Chairman.*

EDITORIAL NOTE

The proposed Tentative Methods of Test for Abrasion Resistance of Rubber Compounds and Test for Compression Set of Vulcanized Rubber were accepted for publication as tentative and appear on pages 1150 and 1164, respectively.

The new proposed Tentative Specifications for Insulated Wire and Cable: Class A, 30 per cent Hevea Rubber Compound, which were formerly included in the existing Tentative Specifications for Insulated Wire and Cable: 30 per cent Hevea Rubber, were accepted for publication as tentative and appear on page 1126. The Tentative Specifications for Insulated Wire and Cable: 30 per cent Hevea Rubber, revised to cover only the class AO rubber compound, were accepted and appear in their revised form on page 1101.

The revisions of the Tentative Specifications for Friction Tape for General Use for Electrical Purposes were accepted. The specifications in their revised form appear on page 1139.

The Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public and Private Fire Department Use and Method of Test for Hardness of Rubber were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 149 and 167, respectively. The recommendation for the adoption as standard of the Tentative Specifications for Rubber Pump Valves, which appeared in the report as preprinted, was withdrawn at the annual meeting, see Summary of Proceedings, page 19.

The publication as information of the proposed Specifications for Rubber Insulating Blankets for Use Around Electrical Apparatus or Circuits Not Exceeding 3000 Volts to Ground was approved, and the specifications appear in the Appendix, page 522.

Recommendations to Committee E-10 on Standards.—Subsequent to the annual meeting Committee D-11 on Rubber Products presented to the Society through Committee E-10 on Standards the following additional recommendations which were accepted by Committee E-10 on August 22, 1934:

Revisions of Tentative Specifications and Tests for Rubber Insulating Tape and Specifications for Insulated Wire and Cable: Performance Rubber Compound were accepted. The specifications in their revised form appear on pages 1145 and 1128, respectively.

Additional revisions of the Tentative Specifications for Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound and of the Abrasion Test were accepted. The specifications and methods in their revised form appear on pages 1101 and 1150, respectively.

APPENDIX I

PROPOSED SPECIFICATIONS FOR RUBBER INSULATI BLANKETS FOR USE AROUND ELECTRICAL APPARATUS OR CIRCUITS NOT EXCEEDING 3000 VOLTS TO GROUND[1]

These are **proposed specifications** and are published as information c
Suggestions for revision are solicited and should be addressed to the Headqua
of the Society, 260 S. Broad St., Philadelphia, Pa.

1. *Scope*.—These specifications cover rubber insulating blankets
protection of electrical workers from accidental contact with live electr
conductors or apparatus or circuits not exceeding 3000 v. to ground.

2. *Basis of Purchase*.—Purchase orders for material under these speci
tions shall include the size of blankets desired, that is, length and width
Section 10 (*a*)).

MANUFACTURE

3. *Construction*.—The blanket shall be made of a high-grade, to
rubber compound, calendered or molded in smooth-faced sheets with or with
beaded edges, and shall have a strong cotton fabric insert 3½ in. in width a
the two long edges. Each blanket shall be equipped with four non-met
eyelets, one at each corner.

PROPERTIES AND TESTS

Electrical Properties

4. *Voltage Test* (*a*).—The entire area of each blanket, as nearly as pr
cable, shall be tested between electrodes consisting of rectangular metal sh
having smoothly rounded edges and corners. The electrodes shall be of s
dimensions or so placed as to avoid flashover at the edges, and shall b
intimate contact with the blanket surface to prevent corona formation.

NOTE.—Minor variations in contact can be removed by wetting the surfa
by inserting a smooth layer of wet fabric between the electrodes and the blanket

(*b*) A potential of 10,000 v. shall be applied for 3 min. The blanket s
not puncture and shall not become appreciably warm at any spot, nor show
other signs of weakness.

5. *Dielectric Strength*.—A specimen, cut from the selected sample
tested to failure in air between 2-in. disk electrodes with edges rounded
radius of ¼ in., shall show a dielectric strength of not less than 375 v. per
thickness.

6. *Methods of Test*.—All tests necessary to determine the electrical p
erties specified in Sections 4 and 5 shall be made on the rubber exclusive of
fabric, and shall be in accordance with the methods described in Sections 1
17, inclusive, of the Standard Specifications for Rubber Matting for Use Aro
Electrical Apparatus or Circuits Not Exceeding 3000 Volts to Ground (A.S.T
Designation: D 178) of the American Society for Testing Materials.[2]

---

[1] Under the standardization procedure of the Society, these specifications are under the
diction of the A.S.T.M. Committee D-11 on Rubber Products.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 1127.

Physical Properties

7. *Physical Properties.*—Specimens cut from any selected sample and tested in accordance with Section 9 shall conform to the following requirements as to physical properties:

(*a*) *Tensile Strength.*—The tensile strength shall be not less than 1200 lb. per sq. in.

(*b*) *Elongation.*—The elongation at the breaking load shall be such that the original 2-in. gage length of the test specimen shall stretch to not less than 10 in.

(*c*) *Set.*—The set, following a stretch from 2 in. to 8 in., shall not exceed 0.3 in.

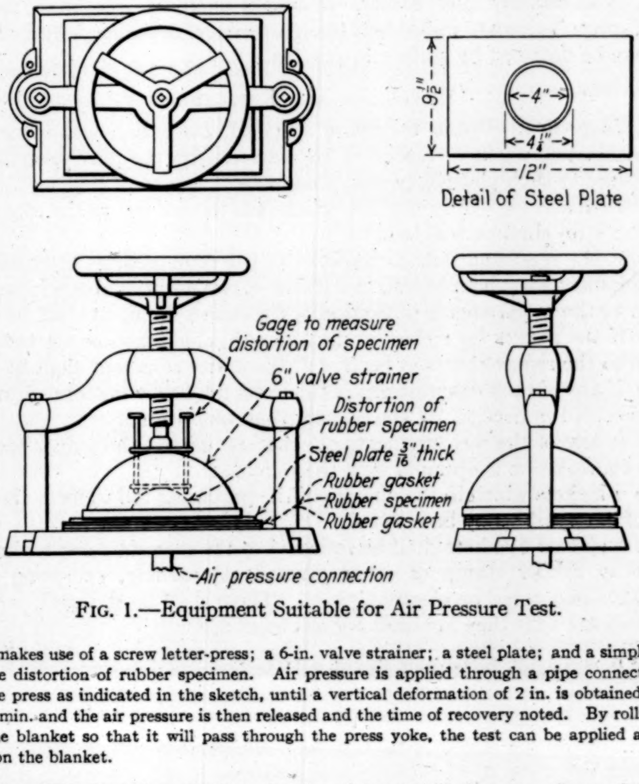

9½"
4"
4¼"
12"
Detail of Steel Plate
Gage to measure distortion of specimen
6" valve strainer
Distortion of rubber specimen
Steel plate 3/16" thick
Rubber gasket
Rubber specimen
Rubber gasket
Air pressure connection

FIG. 1.—Equipment Suitable for Air Pressure Test.

This makes use of a screw letter-press; a 6-in. valve strainer; a steel plate; and a simple lift gage to measure distortion of rubber specimen. Air pressure is applied through a pipe connected to the base of the press as indicated in the sketch, until a vertical deformation of 2 in. is obtained. This is held for 1 min. and the air pressure is then released and the time of recovery noted. By rolling up the ends of the blanket so that it will pass through the press yoke, the test can be applied at selected locations on the blanket.

NOTE.—The test described in Section 8 is provided as an alternative to the tests for physical properties prescribed in Section 7 in cases where it is desired not to destroy a blanket by cutting test specimens.

8. *Air Pressure Test.*—The rubber, exclusive of the fabric, shall stand a vertical deformation of 2 in. without taking a permanent set (10 min. after release) when subjected to air pressure for 1 min. on a circular area 4 in. in diameter. One method of applying the pressure is illustrated in Fig. 1.

9. *Methods of Test.*—All tests necessary to determine the physical properties specified in Section 7 shall be made on the rubber exclusive of the fabric and, where applicable, shall be in accordance with the methods described in

Sections 1 to 9, inclusive, of the Standard Methods of Physical Testin Rubber Products (A.S.T.M. Designation: D 15) of the American Societ Testing Materials.[1]

DIMENSIONS

10. (*a*) ***Length and Width.***—The length and width of blankets shall b specified on the purchase order within permissible variations in length or w of ±0.5 in.

(*b*) ***Thickness.***—The thickness shall be between 0.090 and 0.110 in.

WORKMANSHIP AND FINISH

11. ***Workmanship and Finish.***—Blankets shall be free from punct blisters, protuberances, imbedded foreign matter or other physical de which can be detected by surface inspection.

INSPECTION AND REJECTION

12. ***Inspection.***—Unless otherwise specified, inspection and tests shal made within two weeks of receipt of the material by the purchaser and a own expense at such place as he may designate.

13. ***Rejection*** (*a*).—Any blanket which fails to conform to the requirem of Section 4 (*b*) shall be rejected.

(*b*) If the specimen fails to conform to the requirements of Section 5 entire shipment may be rejected, and if one of two additional specimens fai conform to the requirements of Section 5, the entire shipment shall be rejec

(*c*) If the results for either tensile strength, elongation or set tests, fa conform to the requirements of Section 7, the entire shipment shall be rejec

(*d*) If any of the measurements of thickness fall below the minimum requ ments specified in Section 10, the blanket shall be rejected.

(*e*) If any of the measurements of thickness exceed the values specifie Section 10, rejection is optional with the purchaser.

(*f*) Blankets which in the opinion of the purchaser fail to meet the requ ments of Section 11 may be rejected.

14. Rejected blankets shall be returned to the manufacturer without b defaced by rubber stamp or other permanent marking, excepting blan which have punctured on electrical tests. These shall be stamped, punche cut to indicate that they are unfit for electrical use.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1154.

APPENDIX II

A PROPOSED METHOD FOR TESTING THE ADHESION OF RUBBER TO METAL

By A. H. Flower[1] and H. E. Wening[1]

In recent years there has been a tremendous advance in the use of rubber-adhered-to-metal products. We feel that there should be some standard procedure by which this property of adhesion of the rubber to metal can be accurately evaluated. Through the work of the automotive engineer, there has been developed an unlimited number of types or parts in which there is required a definite adhesion of rubber to metal. It is often stated that there is only one way to test for adhesion and that is on the part itself. Since no two parts are alike, it then becomes necessary to devise equipment that will be applicable to the representative parts. This procedure is now being followed and constitutes a method of control of the manufactured parts.

In the past it was common practice to say that the adhesion of the rubber to metal was equal to or greater than the strength of the rubber. As is generally known, it is possible to show apparent good adhesion of the rubber to metal by reducing the quality of the rubber, and thereby making the adhesion greater than the strength of the rubber. In the event of the use of pure gum and high tensile strength stocks adhered to metal it becomes necessary to have some other means whereby the adhesion of the rubber to metal is recorded.

The present method for the testing of the adhesion of rubber to metal is accordingly proposed. Such a method, to be worthy of consideration, must be easily duplicable and must be reported in terms of standard units. The results of this method are reported as the average pull in pounds per square inch necessary to obtain separation of a cylinder of rubber from metal parts having a cross-sectional area of 2 sq. in. The pull is made at right angles to the adhered surfaces and the results are obtained by slowly separating the jaws of a testing machine at a definite speed until there is a separation of the rubber from the metal or a rupture within the rubber itself.

This paper is not a dissertation on methods whereby adhesion of rubber to metal is obtained, but is confined to discussion of a proposed method for evaluating such adhesion. In the studies which have been made and are described here, the metal parts are given a brass plating. The rubber was vulcanized to the metal by confining the rubber in a steel mold (see detailed drawing of mold, Fig. 7) applying the necessary pressure and heat to cause vulcanization in an ordinary platen press, thereby producing adhesion of the rubber to the metal. This proposed method, however, is applicable in determining adhesion when other means are used, such as plain metal, various cements or metallic oxides.

---

[1] Technical Director, and Rubber Technologist, respectively, Inland Division, General Motors Corp., Dayton, Ohio.

Apparatus:

A 10,000-lb. capacity universal testing machine was used. The speed of testing, that is, the rate of separation of the jaws, was 4 in. per minute. It is necessary to have the required fixtures for attaching the test specimen to the machine and a recording device on the machine to read the total pull in pounds.

Test Specimen:

The adhesion test specimen consists of a rubber cylinder attached to circular metal parts as follows:

Circular Metal Parts.—The circular metal test pieces consist of a smooth flat plate 0.375 in. in thickness and 2 sq. in. in cross-sectional area, equivalent to a diameter of 1.597 in. On the back face of each circular plate there is a round stud ½ in. in diameter by ¾ in. in length, having 20 threads per inch. A detailed drawing of the machined metal part is shown in Fig. 7 and the method of attaching it to the rubber cylinder is illustrated in Figs. 1 and 2. The pieces were machined from hot-rolled bar steel, S.A.E. No. 1020. From this type of bar stock it was possible to obtain a piece with a standard machined smooth flat surface and with the stud on the back. In using a standard steel and a machined smooth surface, it was possible to duplicate the circular metal parts. The stud is used in attaching the specimen to the fixture of the testing machine.

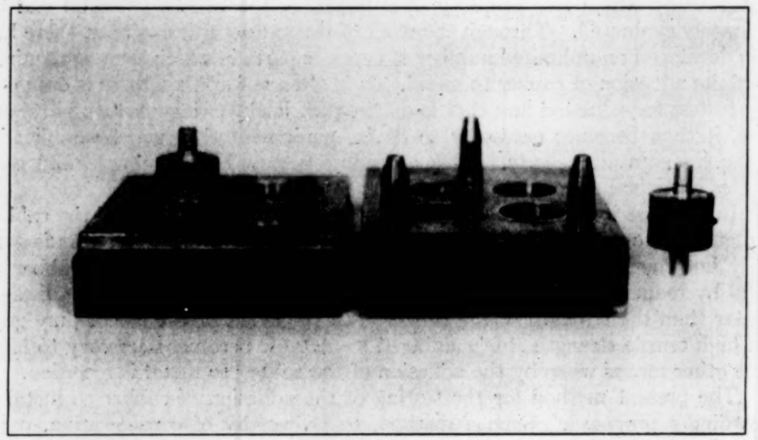


FIG. 1.—Mold and Test Specimen.

Rubber Cylinder.—The rubber cylinder is also 2 sq. in. in cross-section, equivalent to a diameter of 1.597 in. The thickness selected for the rubber cylinder test piece was ½ in. It was thought that, possibly, the results would be affected if too great a thickness of rubber were used, due to large amount of "necking down," that is, reduction in cross-sectional area, of the rubber that would occur during the test. Check tests were accordingly made, using rubber cylinders ¼ in., ½ in., and ¾ in. in thickness, but no appreciable difference in test results was found. All of the tests were made 24 hr. after vulcanization. The circular shape was chosen in order to eliminate sharp corners and also to obtain uniform distribution of the pulling force. The volume of rubber tested is as large as feasible without introducing the possibility of variation of stretch or cure throughout the specimen, which would cause variation in the total pull required to cause complete separation of the rubber and the metal. The mold used for the test specimen is shown in Fig. 1 and is so constructed that there is obtained approximately 0.0015 in. of rubber over the edge of the metal, thus eliminating the tearing of the rubber from the sharp edge of the metal.

Preparation of Test Specimen:

In molding the test specimen it is necessary to have maximum pressure of the rubber against the metal surfaces to which it is to be adhered. To insure this a rubber pellet, slightly thicker than the finished dimension, is loaded in the molds between two metal parts. In the work described, rubber pieces 1⅜ in. in diameter by ¾ in. in thickness were used for making ½-in. test specimens. The time and temperature of the vulcanization must be chosen according to the particular rubber compound used.

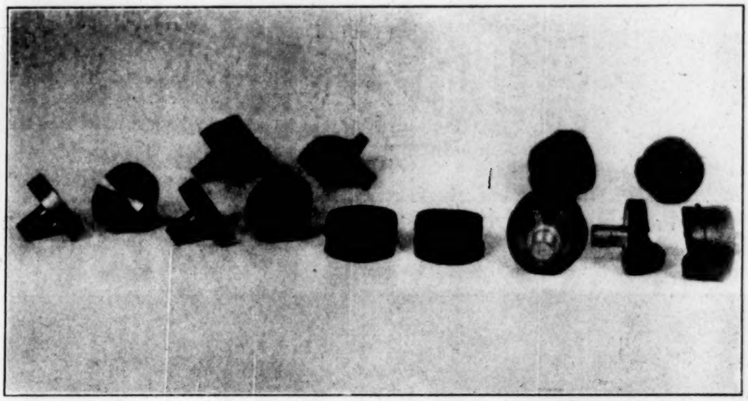


FIG. 2.—Views of Test Specimens, Showing Individual Metal Parts, Metal Test Pieces Cemented, Rubber Cylinders and Finished Test Specimens Before and After Testing.

Testing of Specimen:

The vulcanized test specimens are mounted in the testing machine and a tension pull is applied until the rubber either separates from the metal surface or ruptures. This is illustrated in Figs. 3 to 6, inclusive. The speed of jaw separation of the machine was 4 in. per minute for the results given in Table I. In case of rupture in the rubber, the strength of the adhesion of bond obviously is not measured, but is shown to be greater than the strength of the rubber itself. Notation to this effect should be made on the test report. With high-grade rubber compounds, however, the failure occurs at the rubber metal interface and the maximum applied pull truly evaluates the strength of the adhesion.

Summary:

The results obtained with the method (see Table I) are in good agreement with those obtained on commercial pieces under production conditions. The test specimens show a general higher average of adhesion results than the pro-

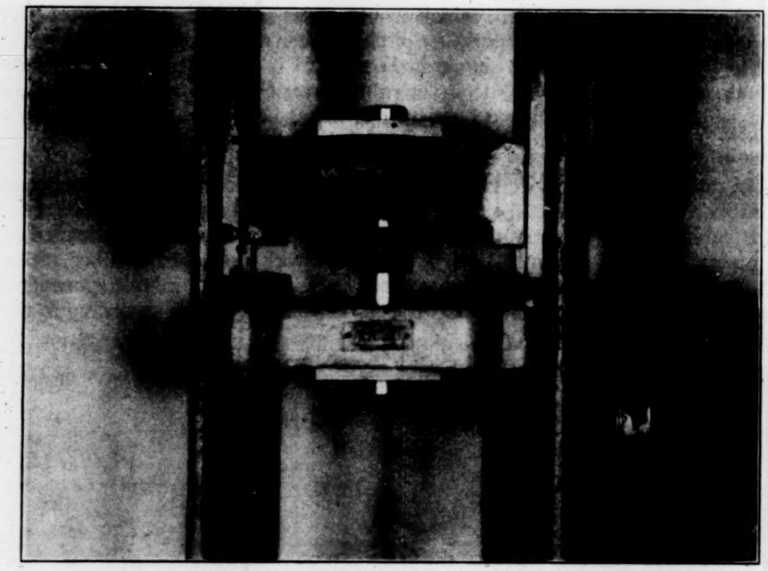


FIG. 3.—Adhesion Test Specimen at Rest in Testing Machine.

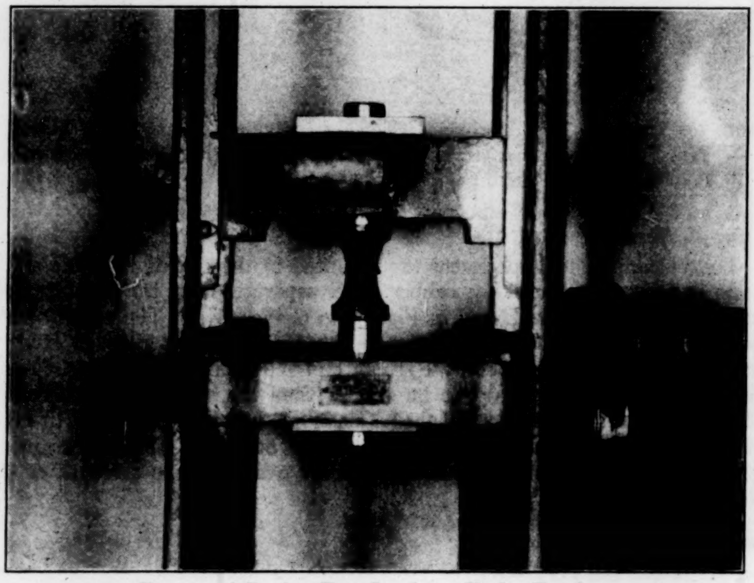


FIG. 4.—Adhesion Test Specimen Under Tension.

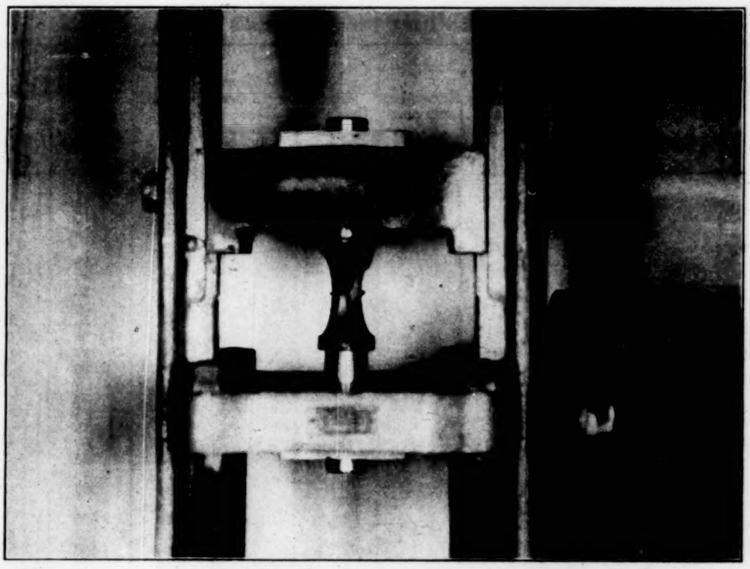


FIG. 5.—Adhesion Test Specimen Showing Start of Tear in the Rubber Cylinder.

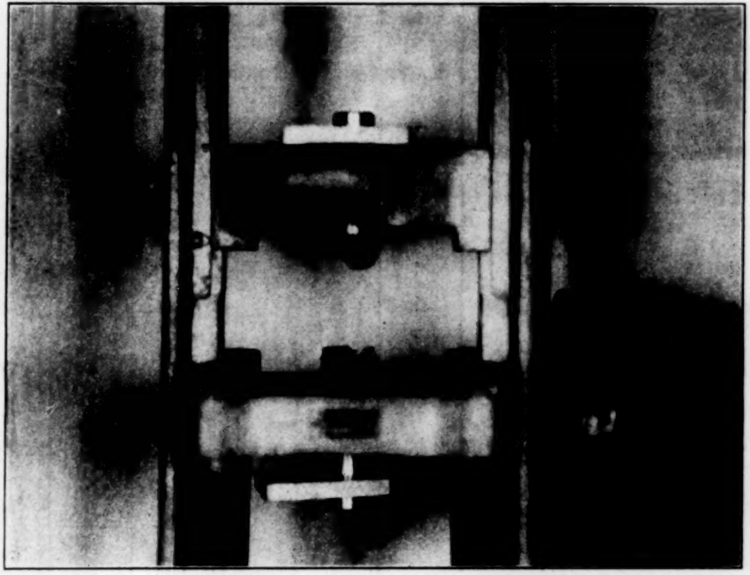
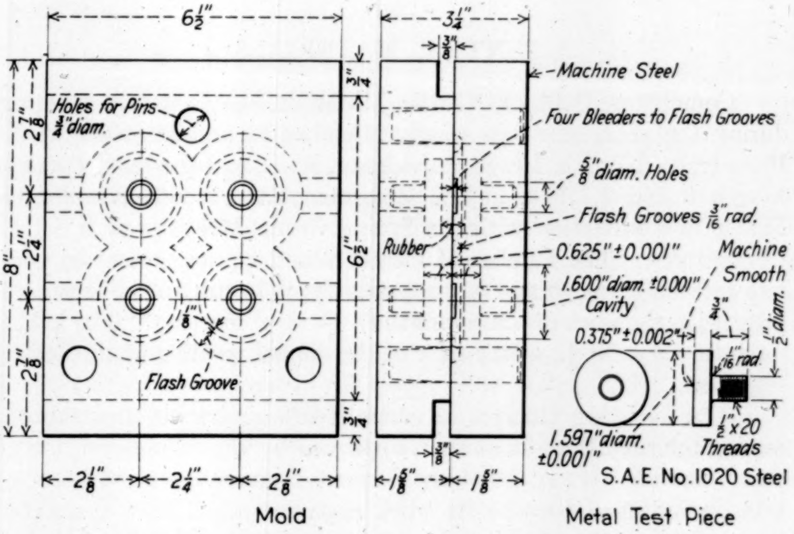


FIG. 6.—Adhesion Test Specimen Showing Complete Separation of the Rubber.

TABLE I.—TYPICAL TEST RESULTS ON VARIOUS FACTORY STOCKS.

Name of Stock	Tensile Strength, lb. per sq. in.	Elongation, per cent	Shore Hardness	Thickness of Rubber Test Specimens, in.	Total Pull, lb.	Adhesion Results	
						Pull, lb. per sq. in.	Average Pull, lb. per sq. in.
Bumper	1150	450	57	$\frac{1}{4}$	950	475	464
					960	480	
					830	415	
					970	485	
				$\frac{1}{2}$	910	455	441
					870	435	
					870	435	
					880	440	
Engine Mounting	3400	650	42	$\frac{1}{2}$	2325	1162	1121
					2364	1182	
					2040	1020	
Auto Running Board Mat	1250	300	80	$\frac{1}{2}$	440	220	257
					550	275	
					430	215	
					560	280	
					490	245	
					680	340	
					445	223	
Engine Mounting	3250	800	34	$\frac{1}{4}$	1180	590	644
					1450	725	
					1180	590	
					1340	670	
				$\frac{1}{2}$	1290	645	658
					1260	630	
					1400	700	
				$\frac{3}{4}$	1710	855	892
					1850	925	
					1790	895	
Engine Mounting	3500	550	52	$\frac{1}{4}$	1180	590	838
					1940	952	
					1540	770	
					2080	1040	
				$\frac{1}{2}$	1960	980	1120
					1790	895	
					2652	1326	
					2562	1281	
				$\frac{3}{4}$	2870	1435	1232
					2630	1315	
					2130	1065	
					2230	1115	
Engine Mounting	2550	875	32	$\frac{1}{2}$	1280	640	688
					1330	665	
					1520	760	
Strip	2700	725	36	$\frac{1}{2}$	290	145	196
					400	200	
					320	160	
					560	280	
Grommet	2440	675	40	$\frac{1}{2}$	460	230	252
					550	275	
					500	250	
Pad	2600	625	42	$\frac{1}{2}$	380	190	244
					440	220	
					490	245	
					640	320	
Spring Bumper	3500	600	55	$\frac{1}{2}$	1050	525	490
					950	475	
					1100	550	
					820	410	

duction pieces, due no doubt to the fact that the test specimens were produced under more ideal conditions. The hardness of the rubber and the type of accelerator used in the compound gave different ranges in the total pull results. Variations in the results have been found due to variations in plating or cementing procedure.



6½"
3¼"
⅜"
Machine Steel
Holes for Pins ¾" diam.
Four Bleeders to Flash Grooves
⅝" diam. Holes
Flash Grooves 3/16" rad.
Rubber
0.625" ±0.001"
Machine Smooth
1.600" diam. ±0.001" Cavity
¾"
½" diam.
0.375" ±0.002"
1/16" rad.
⅛"
Flash Groove
8"
2⅞"
2¼"
2⅞"
¾"
6½"
¾"
1.597" diam. ±0.001"
½" x 20 Threads
S.A.E. No. 1020 Steel
2⅛"
2¼"
2⅛"
1⅝"
1⅝"
Mold
Metal Test Piece

FIG. 7.—Detailed Drawing of Mold and Adhesion Test Piece.

The principal applications for this method of testing the adhesion of rubber to metal are:

(*a*) To assist the compounder in the development of adhesion stocks,

(*b*) To present means whereby the control chemist may test factory batches as to adhesion variation, and

(*c*) To present some method whereby the production company may be able to assist the consumer in specifying the adhesion requirements. It is not directly applicable to inspection testing of production parts since preparation of a special sample is required.

REPORT OF COMMITTEE D-13
ON
TEXTILE MATERIALS

Committee D-13 on Textile Materials has held two meetings during the year; the first was on October 19 and 20, 1933, at the Providence Biltmore Hotel, Providence, R. I., and the second was on March 8 and 9, 1934, at the Wardman Park Hotel, Washington, D. C., in conjunction with the Spring Group Meetings of A.S.T.M. Committees. The number of members and guests present at these two meetings was 70 and 82, respectively, indicating a well-sustained interest in the work of the committee. A third meeting will be held at Atlantic City, N. J., at the time of the annual meeting of the Society in June.

The following changes in committee organization and subcommittee chairmanships have been approved by the Advisory Committee. Section VII on Osnaburg Cement Bags of Subcommittee A-1 was discontinued because its work apparently has been completed. A new Section II on Felt has been organized under Subcommittee A-3 on Wool and Mr. J. F. Marshall was designated as its chairman. Mr. Martin Castricum was appointed chairman of Section IV on Tire Fabrics, Subcommittee A-1, *vice* Mr. B. H. Foster resigned. Mr. R. W. Webb was selected as chairman of Section I on Cotton, Subcommittee A-1, *vice* Mr. H. H. Willis resigned. Mr. H. E. Bishop resigned from the chairmanship of Subcommittee A-7 on Silk and at the present writing the vacancy has not been filled. Changes in the titles of all the "A" subcommittees have been authorized.

The following appointments of members of the committee to represent the Society are recorded: Mr. W. M. Scott and Mr. Ephraim Freedman were named as delegates to a conference called by the American Standards Association to consider standards for the shrinkage of woven cottons; Mr. J. M. Weaver was appointed to the Sectional Committee on Electrical Insulating Materials organized under the procedure of the American Standards Association to coordinate work on these materials in several standing committees and to consider the submission of certain A.S.T.M. standards to the A.S.A. for approval as American Standards. Mr. C. L. Warwick, Mr. G. E. Hopkins, Mr. J. F. Marshall and Mr. H. J. Ball met with representatives of the Society of Automotive Engineers to arrange for cooperation between the two societies in the matter of specifications for automotive felts.

The present membership of the committee is 154, of whom 65 are classified as producer, 47 as consumer, and 42 as general interest members.

RECOMMENDATIONS AFFECTING STANDARDS

The recommendations of the committee regarding standards and tentative standards under its jurisdiction are summarized below together with the analysis of the letter ballot on each item. Comments, where necessary, are made under the Activities of Subcommittees.

I. Proposed Revision of Standards.—The committee recommends the revision of two standards, as indicated below, to become effective immediately. It accordingly asks for the necessary nine-tenths vote at the annual meeting in order that these revisions may be submitted to letter ballot of the Society.

Standard Specifications for Chafer Tire Fabrics (D 316 – 33).[1]—The committee recommends that the definition for crimp be replaced by a new definition, proposed last year for publication as a tentative revision of the Standard General Methods of Testing Woven Textile Fabrics (D 39 – 27), as follows:

Section 10 (b).—Replace the last sentence of this section, which reads as follows:

> The crimp shall be the ratio between the final length of the thread and its original length in the cloth.

by the following sentence:

> The crimp shall be the difference in distance between two points of the yarn as it lies in the fabric, and the same two points when the yarn has been removed from the fabric and straightened, expressed as a percentage of the distance between the two points as the yarn lies in the fabric.

Standard General Methods of Testing Woven Textile Fabrics (D 39 – 27).[2]—The committee recommends that the shrinkage test which was proposed last year for publication as a tentative revision of the Standard Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (D 274 – 29), be incorporated in its improved editorial form, as appended hereto,[3] in Methods D 39 as new Sections 14 to 21.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1215.

[2] *Ibid.*, p. 1224.

[3] The shrinkage test procedure has been incorporated in the Standard Specifications D 274. The specifications in their revised form appear in the 1934 Supplement to Book of A.S.T.M. Standards, p. 187.—ED.

II. Proposed Revision of Tentative Standards.—The committee is presenting changes in the following tentative standards and recommends that, as revised, they be continued as tentative:

Tentative Definitions and Terms Relating to Textile Materials (*D 123 - 33 T*).[1]—Change the definition of "Twist, Direction of" from its present form: namely,

Twist, Direction of.—In the case of yarn or cord, the yarn or cord has right-hand or regular twist if when it is held vertically the spirals or twists are seen to incline upward in a right-hand direction and has left-hand or reverse twist when the spirals or twists are seen to incline upward in a left-hand direction.

NOTE.—Attention is called to the fact that this definition of twist is opposite to that used in sewing thread manufacture.

to read as follows:

Twist, Direction of.—In the case of yarn or cord held in a horizontal position and fixed at the left end, if the twist is taken out by turning to the right, or clockwise, when viewed from the right end, it is right twist, and, if the twist is taken out by turning to the left, or counter-clockwise, when viewed from the right end, it is left twist; that is, the yarn or cord has right twist if, when it is held vertically, the spirals or twists are seen to incline upward to the right, and has left twist if the spirals or twists are seen to incline upward to the left.

NOTE.—This definition is used by the cotton and wool industries. Due to trade custom, the opposite of this definition is used by the sewing thread, silk, and rayon industries.

Tentative Specifications for Holland Cloth (*D 376 - 33 T*):[2]
Section 6.—Change from its present form: namely,

6. The finish shall be smooth and shall not flake when subjected to recognized factory test. Rejection for finish shall be made within 30 days of receipt of material.

to read as follows:

6. When Holland cloth is applied to a tacky gum surface under conditions similar to those existing in commercial practice and is then snapped or plucked from the gum stock, there shall be no starch particles left adhering to the gum surface. Rejections for this defect shall be made within 30 days of receipt of the material. It is understood that this requirement applies to No. 1 construction only.

III. Adoption of Tentative Standards as Standard.—The committee recommends that the following three tentative standards be adopted as standard:

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 944 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 970.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 924 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 926.

Tentative Specifications and Test Methods for Cotton Goods for Rubber and Pyroxylin Coating (D 334 - 31 T).[1]

Tentative Specifications for 0.007-in. Cotton Tape (D 335 - 31 T);[1]

Tentative Method of Determining Relative Humidity (D 337 - 31 T);[1]

IV. Adoption of Tentative Revisions of Standards as Standard.—The committee recommends the submission of the following tentative revisions of standards, as proposed in the report of the committee for 1933, to letter ballot of the Society for adoption and incorporation in the respective standards:

Revision of Standard Specifications for Tolerances for Hose Ducks and Belt Ducks (D 181 - 33), covering the addition of methods of testing;[2]

Revision of Standard Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (D 274 - 29), covering the shrinkage test, Sections 9 to 13, inclusive, revised editorially, as appended hereto;[3]

Revision of Standard General Methods of Testing Woven Textile Fabrics (D 39 - 27), covering Section 13 on Crimp.[4]

V. Tentative Standards and Revisions Continued.—The committee recommends that all other tentative standards and tentative revisions of existing standards not specifically referred to under Activities of Subcommittees be continued as tentative for another year.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 154 members, with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF STANDARDS			
Specifications for Chafer Tire Fabrics (D 316 - 33), immediate adoption	33	0	32
General Methods of Testing Woven Textile Fabrics (D 39 - 27), immediate adoption	45	0	20
II. PROPOSED REVISION OF TENTATIVE STANDARDS			
Definitions and Terms Relating to Textile Materials (D 123 - 33 T)	57	2	6
Specifications for Holland Cloth (D 376 - 33 T)	23	2	35
III. ADOPTION OF TENTATIVE STANDARDS AS STANDARD			
Specifications and Test Methods for Cotton Goods for Rubber and Pyroxylin Coating (D 334 - 31 T)	25	2	38
Specifications for 0.007-in. Cotton Tape (D 335 - 31 T)	25	0	40
Method of Determining Relative Humidity (D 337 - 31 T)	46	0	19
IV. ADOPTION OF TENTATIVE REVISION OF STANDARDS AS STANDARD			
Specifications for Tolerances for Hose Ducks and Belt Ducks (D 181 - 33)	27	1	37
Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (D 274 - 29)	40	0	25
General Methods of Testing Woven Textile Fabrics (D 39 - 27)	50	1	14

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, pp. 982, 988, 1005 (1931); also 1933 Book of A.S.T.M. Tentative Standards, pp. 920, 940, 966.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 1044 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 1082.

[3] The shrinkage test procedure has been incorporated in the Standard Methods D 39. The methods in their revised form appear in the 1934 Supplement to Book of A.S.T.M. Standards, p. 204.—ED.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 1047 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 1085.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee A-1 on Cotton and Its Products (K. B. Cook, chairman):

Section I on Cotton (R. W. Webb, chairman).—This recently reorganized section held an exceptionally successful and interesting meeting in March, 1934, to consider the fundamentals of cotton fiber quality. The section was made acquainted with the extensive work of the cotton fiber laboratories of the U. S. Bureau of Agricultural Economics and their thorough studies of the length, strength, fineness, maturity, and color of raw cotton. Based upon such fundamental research, the section expects during the coming year to present specifications for and methods of measurement of cotton fiber quality. It is planned to hold two meetings in the South where the cotton breeding, production, and ginning problems can be observed and discussed to particular advantage.

The following papers were presented before the section:

"The Problem of Character in Raw Cotton," by C. M. Conrad;

"The Importance of Cooperation Between the Cotton Textile Industry and the Cotton Breeder," by D. R. Coker;

"Determinations of Fineness and Maturity of Cotton Fibers," by T. L. W. Bailey, Jr.; and

"Improvements in the Chandler Bundle Method for Measuring Strength of Cotton Fibers," by H. B. Richardson.

Section II on Cotton Yarns (R. H. Adams, chairman).—This section has continued its compilation of data for the purpose of revising the present trade standards of yarn strength.

Section III on Light and Medium Cotton Woven Fabrics (R. T. Fisher, chairman).—This section is recommending that the shrinkage test, which has stood for a year as a tentative revision of the Standard Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (D 274 – 29), be adopted as standard and incorporated in the specifications. No objections to it have been received. It is recommended that the reworded form as appended hereto,[1] and referred to under Subcommittee B-1, Section I on Methods, be used.

The section also recommends that the Tentative Specifications and Test Methods for Cotton Goods for Rubber and Pyroxylin Coating (D 334 – 31 T) be adopted as standard. There has been no criticism of these specifications during their three years in the tentative status.

This section expects to have a full program during the coming year if the plans of the Federal Government for consumer standards develop.

---

[1] The shrinkage test procedure has been incorporated in the Standard Specifications D 274. The specifications in their revised form appear in the 1934 Supplement to Book of A.S.T.M. Standards, p. 187.—ED.

Section IV on Tire Fabrics (Martin Castricum, chairman).—This section is presenting a revision in the Tentative Specifications for Holland Cloth (D 376 – 33 T), as given earlier in this report. This revision is for the purpose of clarifying, as adequately as possible, the requirement for finish in the matter of flaking. It is hoped by further study of this flaking or plucking test to develop a more exact procedure. The section recommends that the correct definition of crimp, which is being recommended for adoption as standard by Subcommittee B-1, Section I on Methods, be substituted for the incorrect wording now appearing in Section 10 (*b*) of the Standard Specifications for Chafer Tire Fabrics (D 316 – 33).[1]

The section is at work upon specifications for single yarn chafer tire fabrics, upon the development of a fatigue test for tire cord, and is conducting further study of the adequacy of the present standard method of calibrating tire cord tension testing machines.

Section V on Hose, Belt, and Numbered Duck (B. L. Whittier, chairman).—This section recommends that the tentative revision of the Standard Specifications for Tolerances for Hose Ducks and Belt Ducks (D 181 – 33), which comprises methods of testing procedure, be adopted as standard. This revision has been standing as tentative for a year and no objection to it has been raised.

This section is planning to draw up methods of test applicable to numbered ducks and to incorporate them in the Standard Specifications for Tolerances for Numbered Cotton Duck (D 230 – 27). It has also requested the development of a suitable method of determining the unit weight of cotton goods based on the entire piece. This matter has been referred to Subcommittee B-1, Section I on Methods.

Section VI on Narrow Fabrics (F. S. Mapes, chairman).—This section recommends the adoption as standard of the Tentative Specifications for 0.007-in. Cotton Tape (D 335 – 31 T). These specifications have been standing as tentative for three years and no unfavorable criticisms have been received during this time. The section also recommends that the Tentative Specifications for Tolerances and Test Methods for Silk and Cotton Tapes (D 259 – 31 T) be continued as tentative another year pending a decision regarding methods of measuring thickness.

The section proposes to contact the larger producers and users of typewriter ribbons for the purpose of forming a subsection which will prepare test methods and eventually specifications for this product.

---

[1] Additional revisions of the Standard Specifications D 316 were presented to Committee E-10 on Standards subsequent to the annual meeting for publication as tentative, see Editorial Note, p. 542.—ED.

Section VIII on Sewing Threads (F. S. Cobb, acting chairman).—This section is working in conjunction with a testing machine manufacturer to develop a method of reeling sewing threads under a definite tension. It is felt that its use would give greater definiteness to the results of the present methods for determining yardage and length of package described in the Standard Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 – 33).

Subcommittee A-2 on Rayon and Its Products (A. M. Tenney, chairman):

Section I on Rayon (A. M. Tenney, chairman).—This section is considering a revision of the Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 – 32 T) for the purpose of bringing the definition of twist in Section 10 of these specifications into agreement with the revised definition which is being offered by Subcommittee B-2 on Nomenclature and Definitions. The section is working cooperatively with the American Association of Textile Chemists and Colorists on complete revisions of the above-mentioned specifications which, when completed, will recognize the most recent developments in the manufacture of rayon.

Section II on Rayon Fabrics (Alexis Sommaripa, chairman).—This section reports that tentative methods for measuring the breaking strength of rayon fabrics when wet are nearing completion and it expects to present them during the coming year. Work which has been started upon methods of testing rayon fabrics for launderability and for unraveling will be continued.

Subcommittee A-3 on Wool and Its Products (G. E. Hopkins, chairman):

Section I on Wool (G. E. Hopkins, chairman).—This section has continued its work of completely revising the Tentative Methods of Testing Grease Wool and Allied Fibers for Scoured Content (D 232 – 25 T) and plans to present the results in the very near future.[1] Until such time, it recommends that these methods be continued as tentative. The section also has practically completed new specifications for woolen yarns[2] and definite recommendations will soon be placed before the committee.

For new work the section is planning to prepare specifications for worsted yarns, test methods for woven pile fabrics, and test methods to determine the clean content of greasy wool. At a recent meeting of the Advisory Committee the chairman of this section was authorized to take such steps as seem advisable to secure the adoption by the woolen industry of a single standard system of numbering woolen yarns.

---

[1] A revision of these methods was presented to Committee E-10 on Standards subsequent to the annual meeting for publication as tentative, see Editorial Note, p. 542.—ED.

[2] Specifications for Woolen Yarns and Worsted Yarns were presented to Committee E-10 on Standards subsequent to the annual meeting for publication as tentative, see Editorial Note, p. 542.—ED.

Section II on Felt (J. F. Marshall, chairman).—This section is actively at work upon specifications for felt. As a result of an understanding with representatives of the Society of Automotive Engineers, that society will look to this section to develop suitable methods of test to which reference can be made in the S.A.E. specifications for automotive felts. Furthermore, it is planned that the provisions of the specifications, prepared by this section, which relate to felts used in the automotive trade shall be in agreement with those developed by the S.A.E.

Subcommittee A-4 on Asbestos and Its Textile Products:[1]

Section I on Asbestos Textiles (J. M. Weaver, chairman).—This section has undertaken the work of determining the electrical resistivity of asbestos tapes.

Subcommittee B-1 on Methods and Machines (W. D. Appel, chairman):

Section I on Methods (W. D. Appel, chairman).—Members of this section and of Committee D-13, who are closely identified with the interests of the Federal Specifications Board and of the American Association of Textile Chemists and Colorists, have collaborated to secure uniformity in the shrinkage test procedure which is common to these organizations and which now stands as a tentative revision of the Standard Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (D 274 – 29). In consequence, certain editorial changes have been made in the original wording but without change in substance. The section recommends that the shrinkage test procedure, as appended hereto,[2] in its improved editorial form, after adoption as standard, be added to the Standard General Methods of Testing Woven Textile Fabrics (D 39 – 27).

The section also recommends that the tentative revision of the Standard General Methods of Testing Woven Textile Fabrics (D 39 – 27), pertaining to Section 13 on Crimp, be adopted as standard. This revision is in the nature of a correction of the present wording and brings it into agreement with the definition of crimp contained in the Tentative Definitions and Terms Relating to Textile Materials (D 123 – 33 T).

---

[1] Revisions of the existing Standard Specifications for Asbestos Yarns (D 299 – 33) and the Tentative Specifications for Asbestos Roving (D 375 – 33 T) were presented to Committee E-10 on Standards subsequent to the annual meeting, see Editorial Note, p. 542.—ED.

[2] The shrinkage test procedure has been incorporated in the Standard Specifications D 274 and in the Standard Methods D 39. The specifications and methods in their revised form appear in the 1934 Supplement to Book of A.S.T.M. Standards, pp. 187 and 204, respectively.—ED.

The section is planning to give further study to the tentative revision of the Standard General Methods of Testing Woven Textile Fabrics (D 39 - 27) relating to elongation which it believes to be too indefinite in its present form. The section is working on a specification for the diameter of drums for testing multiple ply yarns and cords and on a standard procedure for a serigraph method of testing yarns. This section, at the request of Subcommittee A-1, Section V, will also develop a method of determining the unit weight of cotton goods based on the entire piece.

A communication has been received from Committee E-1, Technical Committee VIII on Thickness Measurements, W. E. Emley, chairman, calling attention to the desirability of reducing the number of methods of measuring thickness which appear in the standards of Committee D-13. The matter has been referred to this section and an effort will be made to bring about a greater degree of standardization.

Section II on Machines (H. J. Ball, chairman).—This section has had referred to it for consideration the matter of a revision of the Standard Specifications for Textile Testing Machines (D 76 - 33) to include appropriate recommendations regarding the constant-rate-of-load type of strength tester.

Section III on Humidity (G. B. Haven, chairman).—This section is recommending that the Tentative Method of Determining Relative Humidity (D 337 - 31 T) be adopted as standard. No criticism has been received during the three years in which it has been in a tentative status.

The section is planning to gather data on standard regain values for various textile materials.

Subcommittee B-2 on Nomenclature and Definitions (A. L. Brassell, chairman):

For the purpose of clarifying the definition of "Twist, Direction of," which appears in the Tentative Definitions and Terms Relating to Textile Materials (D 123 - 33 T), this section is proposing a revision of the definition, as given earlier in this report, and recommends that the tentative standard as thus revised be continued as tentative.

The Advisory Committee has recommended that the Tentative Definitions and Terms Relating to Textile Materials (D 123 - 33 T) should contain only those terms of a technical and scientific character which appear in the A.S.T.M. standards on textile materials. During the coming year the section is planning to review the present list of terms and make the recommended change. Those terms which do not find a place in the standards, together with many others which are now under consideration, will be used to form the basis of a much-needed glossary for the textile industry.

Subcommittee B-4 on Bleaching, Dyeing and Finishing (W. M. Scott, chairman):

This section reports that the experimental work on a method for the determination of sizing materials in textiles is nearing completion and that definite recommendations will be made soon. Additional projects which are engaging the attention of this active section are suitable tests for fastness of dyed fabrics to washing and to light, methods for determining the presence of oxycellulose and hydrocellulose in bleached cotton fabrics, a method for testing the waterproofness of fabrics, and a method of testing detergency.

Subcommittee on Papers (Dean Harvey, chairman):

This subcommittee has provided papers for the general sessions of Committee D-13 which have been helpful to the members in their work and which have given them information on new developments in connection with textiles. The following papers were presented:

"Strain Measurements of the Band Ply of an Inflated, Loaded Pneumatic Tire," by H. W. Buckwalter;

"An Improved Method for Converting an Observed Skein Strength to That for a Specified Count," by M. E. Campbell;

"Recent Developments in Testing Apparatus," by Alfred Suter;

"Demonstration of New Method of Determining Single Ply and Cable Twists as They Lay in the Cord," by J. M. Scott;

"Sanforizing," by H. D. Clayton;

"A Method of Analyzing Cotton Yarn Strength Data," by M. E. Campbell;

"Discussion of Statistical Analysis as Applied to Tire Fabric Testing," by W. R. Marsden;

"The Relation of Tensile Strength to Rate of Load," by D. C. Scott.

The following officers were elected for the two-year period from June, 1934, to June, 1936:

Chairman, H. J. Ball
First Vice-Chairman, B. H. Foster
Second Vice-Chairman, J. M. Weaver
Secretary, W. H. Whitcomb

This report has been submitted to letter ballot of the committee, which consists of 154 members; 65 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. J. BALL,
Chairman.

W. H. WHITCOMB,
Secretary.

EDITORIAL NOTE

The revisions proposed for immediate adoption in the Standard Specifications for Chafer Tire Fabrics and General Methods of Testing Woven Textile Fabrics were unanimously approved at the annual meeting and were subsequently adopted by letter ballot of the Society on September 1, 1934. The standards in their revised form appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 191 and 204, respectively.

The revisions of the Tentative Definitions and Terms Relating to Textile Materials and Specifications for Holland Cloth were accepted. The definitions and specifications in their revised form appear on pages 1186 and 1175, respectively.

The Tentative Specifications for 0.007-in. Cotton Tape and Method of Determining Relative Humidity were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 202 and 211, respectively. The Tentative Specifications and Test Methods for Rubber and Pyroxylin Coating, recommended on the floor of the annual meeting for adoption as standard, see Summary of Proceedings, page 18, were subsequently adopted as standard by letter ballot of the Society on September 1, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, page 196.

The tentative revisions of the Standard Specifications for Tolerances for Hose Ducks and Belt Ducks, for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics, and General Methods of Testing Woven Textile Fabrics were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1934. The standards in their revised form appear in the 1934 Supplement to Book of A.S.T.M. Standards, pages 184, 187 and 204, respectively.

Recommendations to Committee E-10 on Standards.—Subsequent to the annual meeting Committee D-13 on Textile Materials presented to the Society through Committee E-10 on Standards the following additional recommendations which were accepted by Committee E-10 on August 22, 1934:

Proposed Tentative Specifications for Tolerances and Test Methods for Woolen Yarns and Tolerances and Test Methods for Worsted Yarns were accepted for publication as tentative and appear on pages 1178 and 1181, respectively.

Revision of the Tentative Specifications for Asbestos Roving was accepted and the specifications in their revised form appear on page 1169.

Revisions of the Tentative Methods of Testing Grease Wool and Allied Fibers for Scoured Content in the form of completely revised methods entitled, "Tentative Method of Estimating Hard Scoured Wool in Wool in the Grease" were accepted and the revised methods appear on page 1184.

Tentative revisions of the Standard Specifications for Chafer Tire Fabrics were accepted and appear on page 533.

Tentative revisions of the Standard Specifications for Asbestos Yarns in the form of separate tentative specifications were also accepted. The specifications in their revised form appear on page 1172.

REPORT OF COMMITTEE D-15

ON

THERMOMETERS AND LABORATORY GLASSWARE

During the past year the scope and title of Committee D-15 have been extended to include laboratory glassware and the membership of the committee has been enlarged by the addition of representatives of apparatus manufacturers. The standing committees of the Society having an interest in the standardization of laboratory glassware have also designated representatives on Committee D-15.

The committee has held two meetings during the year and has given consideration to a number of problems relating to glass apparatus embodied in specifications or methods of testing sponsored by some of the standing committees, and in several cases has made definite recommendations for the correction or revision of an apparatus design or description. The purpose of such recommendations may be to increase the accuracy of the apparatus, to provide more reasonable or proper tolerances, or to describe the apparatus in terms that will avoid misinterpretation on the part of the manufacturer. These recommendations have been well received and are being given consideration for action on the part of the committees involved.

Recommendations Affecting Standards

The attention of the committee has been directed to some misunderstandings which had arisen in a number of the thermometer specifications concerning the section on Test for Permanency of Range in that there was no definite statement as to the immersion conditions under which the test should be made. In order to clarify the intent of the requirement, the committee recommends as an editorial revision the addition of the following sentence to the Section on Test for Permanency of Range in the thermometer requirements of all A.S.T.M. methods and specifications in which this test is included:

> The test shall be made under the immersion conditions specified for this thermometer.

The specifications and methods of testing to which this additional sentence should be added are as follows:

Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 – 30);
Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 – 30);

- Standard Method of Test for Flash and Fire Points by Means of Open Cup (D 92 – 33);
- Standard Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (D 93 – 22);
- Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, –5 to +400 C., +20 to +760 F. (D 184 – 25);
- Standard Method of Test for Distillation of Natural Gasoline (D 216 – 32);
- Standard Method of Test for Distillation of Creosote Oil (D 246 – 33);
- Standard Method of Test for Water in Creosote Oil (D 370 – 33);
- Tentative Method of Test for Residue of Specified Penetration (D 243 – 32 T).

The Tentative Specifications for Thermometers for Engler Viscosimeters (D 300 – 30 T) have been in use for four years during which time no criticisms have been received concerning them. The committee, therefore, recommends that these specifications be approved for reference to letter ballot of the Society for adoption as standard. This recommendation has been submitted to letter ballot of the committee, which consists of 17 members; 15 members returned their ballots, of whom 14 have voted affirmatively, none negatively and 1 has marked his ballot as "not voting."

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee which consists of 17 members; 15 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

W. H. FULWEILER,
Chairman.

C. S. REEVE,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Thermometers for Engler Viscosimeters were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on October 15, 1934, and appear in the 1934 Supplement to Book of A.S.T.M. Standards, page 215.

REPORT OF COMMITTEE D-17
ON
NAVAL STORES

Committee D-17 on Naval Stores has been unable to get a sufficient number of its members together to hold a formal meeting for the consideration of its problems. Such work as has been done has been accomplished entirely through correspondence. As has been the case in recent years the work has been badly handicapped by reduced personnel, overwork and lack of funds in the laboratories of the members of the committee. These conditions have been beyond the control of the committee members and are recorded as a matter of information and explanation of the lack of greater activity on the part of the committee.

Subcommittee II on Crystallization (E. V. Romaine, chairman) has been quite active during the past year and in its report appended hereto there is presented a brief résumé of the many uses for which non-crystallizing rosin is essential, and a very interesting discussion of methods for determining the crystallization tendency of rosin. Results of crystallization tests on different solutions of some six different samples of rosin in various oils are presented.

Attention is called to the use of the hand spectroscope as suggested by W. C. Smith[1] for determining end point in acid number and saponification number titrations in the case of dark colored rosin.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee, which consists of 16 members; 14 members returned their ballots, of whom 13 have voted affirmatively, and 1 negatively.

Respectfully submitted on behalf of the committee,

F. P. Veitch,
Chairman.

---

[1] W. C. Smith, "Acidity Titration of Low Grade Rosins," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 6, No. 2, p. 122 (1934).

Certain industrial uses for rosin require that it shall be readily and permanently soluble at various rosin concentrations in a variety of solvents and oils or mixtures of certain solvents and oils; that is, under the conditions required for the manufacture, storage and use of the solution, the rosin shall readily dissolve in the solvent or oil and shall not crystallize out on standing.

Investigation of these uses for rosin revealed the following facts:

1. The principal industrial uses are: Printing ink, varnishes, core oils, artificial shellac, synthetic rosin oil and certain pitches, such as artificial Burgundy pitch.
2. The rosin concentration may range from 5 per cent to 85 or 95 per cent by weight.
3. The solvents may be alcohol (methyl or ethyl): or lacquer solvents, such as butyl alcohol, amyl alcohol, amyl acetate, etc.; or the coal tar solvents, such as benzol, toluol, xylol, etc.
4. The oils may be mineral, vegetable or animal oils, or mixtures of these oils.
5. The conditions under which the solution may be made vary from dissolving the rosin at atmospheric temperatures to dissolving it at temperatures as high as 200 C., or possibly higher. The time of heating may vary from one to three or four hours. The time of storage may be from one day to many months.
6. In some cases mechanical agitators are used, while in other cases the solutions are agitated by hand.
7. In some cases the rosin is used as is, while in other cases the rosin is partially neutralized with an inorganic or organic base, such as calcium hydrate, sodium or potassium hydrate, glycerine, etc.
8. Rosin crystallization is more prevalent in those preparations where the rosin concentration ranges from 20 to 75 per cent by weight.
9. Wood and gum rosins are used.

From the foregoing facts it is very evident that the conditions under which all of these preparations are made, used and stored, are extremely variable; that a rosin may be suitable for some but not for all preparations; and that a rosin might be satisfactory for all of the preparations, if each is made and stored under certain conditions.

It is obvious, therefore, that a satisfactory method of test for determining the permanent solubility (crystallization) of rosin in the different solutions must cover widely different conditions and must be applicable to the different grades and brands of gum and wood rosins.

Optical Rotation of Rosin:

From what literature there is on the subject, it is indicated that the optical rotation of rosin is indicative of its permanent solubility, and the greater the degree of dextro rotation, the longer will it be required for a rosin to crystallize from a given solution. In other words, a rosin having an optical rotation of +40 would remain in solution for a longer time than one having a rotation of +20, and this in turn would not crystallize as quickly as one having a rotation of zero.

As the optical rotation is a simple, rapid and accurate determination to make, the committee felt that it would be an ideal method from the commercial standpoint, providing it would reveal the desired information. In order to determine whether tendency to crystallize from solution bears a close relation to the optical rotation of the rosin, six different rosins were tested. Their constants and optical rotations are given in Table I.

TABLE I.—ANALYSES OF ROSINS USED IN CRYSTALLIZATION STUDIES.

	ROSIN No. 1	ROSIN No. 2	ROSIN No. 3	ROSIN No. 4	ROSIN No. 5	ROSIN No. 6
U. S. Color Grade	*N*	*FF*	*F*	*FF*	*FF*	*M*
Melting Point (Capillary Tube Method), deg. Cent.	52	55	65	54	56	59
Melting Point (Ring-and-Ball Method) deg. Cent.	72	75	85	75	77	80
Acid Number	147	140	162	125	153	163
Saponification Number	155	150	174	135	165	170
Ash, per cent	0.01	0.02	0.05	0.01	0.02	0.01
Optical Rotation	+25	+8	+25	+28	+3	+2

Two procedures were used in making these tests. For identification purposes these are designated "The Solution Method" and "Low-Temperature Heat Treatment Method."

Solution Method:

In Table II there has been tabulated, for each of the several types of rosin listed in Table I, the rosin concentration of different solutions using several different oils, the date the solutions were prepared and the date the crystals were first noted. The solutions were made as follows:

The solutions were prepared by placing the rosin and solvent in an Erlenmeyer flask and connecting the flask to a reflux condenser. The mixture was carefully heated with a naked flame and the temperature slowly raised to 100 C. where it was held until solution was complete. Then the temperature was raised as rapidly as possible to 150 C. where it was held for 30 minutes. The solution was then permitted to cool to room temperature when it was transferred into a 4-oz. oil sample bottle, tightly stoppered and set aside for observation. Until the rosin was entirely dissolved the contents of the flask were frequently agitated by whirling the flask by hand. The object of this was to prevent any possible super-heating of the rosin. For identification purposes this procedure is referred to as the solution method.

The results of the experiments recorded in Table II very definitely show that the mineral oils are quite superior to linseed oil as rosin solvents; that the paraffin-base oil is not as good a solvent as the asphaltum-base oil; and that kerosine and asphaltum-base oils are about equal.

Referring to the different types of rosin, from a study of their constants as well as their crystallizing tendencies, it will be observed that the most permanently soluble rosin of all is No. 4, there being no crystals present in either the kerosine or linseed oil solutions, in which the rosin concentration was 50 per cent by weight, after standing for 3½ years. The analysis of the rosin shows that it has the lowest acid number and somewhat the highest dextro rotation.

TABLE II.—RESULTS OF CRYSTALLIZATION STUDIES OF ROSIN DISSOLVED IN DIFFERENT OILS.

Sample	Kind of Rosin.	Rosin Concentration, per cent by Weight	Kind of Oil	Date Sample Prepared	Date Crystals Were First Noted
A	No. 1	50	Paraffin base	May 5,1932	May 16, 1932
B	No. 1	35	Paraffin base	May 5, 1932	May 1, 1933
C	No. 1	50	Asphaltum base	May 5, 1932	May 1, 1933
D	No. 1	35	Linseed Oil (raw)	Dec. 10, 1932	April 4, 1933
E	No. 2	40	Kerosine	Sept. 1, 1930	None to date
F	No. 2	30	Linseed Oil (raw)	Sept. 1, 1930	Oct. 1, 1930
G	No. 3	50	Kerosine	Sept. 1, 1930	Nov. 1, 1933
H	No. 3	35	Linseed Oil (raw)	Sept. 1, 1930	Dec. 1, 1931
I	No. 4	50	Kerosine	Sept. 1, 1930	None to date
J	No. 4	50	Linseed Oil (raw)	Sept. 1, 1930	None to date
K	No. 5	30	Kerosine	Sept. 1, 1930	None to date
L	No. 5	30	Linseed Oil (raw)	Sept. 1, 1930	Sept. 3, 1930
M	No. 6	50	Kerosine	June 30, 1932	Sept. 3, 1932
N	No. 6[a]	50	Kerosine	June 30, 1932	None to date

[a] After treating with 4 per cent of lime (calcium hydrate).

The next most permanently soluble rosin is No. 3. This rosin has the highest acid number, exceeding that of rosin No. 4 by 37, and an optical rotation of +25.

The third rosin in order of permanent solubility is No. 2. Here the acid number is found to be about midway between that of rosins Nos. 3 and 4 with an optical rotation of + 8.

Rosin No. 5 shows the greatest tendency to crystallize, crystals appearing in both the kerosine and linseed oil solutions at a rosin concentration of 30 per cent on the second day after preparation. The acid number of this rosin is somewhat lower than that of No. 3 and higher by 48 than that of No. 4. The optical rotation, however, is only + 3.

Of these four types of rosin the optical rotation appears to indicate the trend of crystallization. Rosin No. 4, having a rotation of +28, shows no signs of crystallization under conditions of the tests in linseed oil after 3½ years; rosin No. 3 crystallized in 15 months and rosin No. 5, which has an optical rotation of only + 3, crystallized in 2 days.

Referring to rosin No. 1 the conditions will be found to be reversed. This rosin has an optical rotation of +25, the same as rosin No. 3, but it crystallized from linseed oil in 4 months, whereas No. 3 required 15 months to show crystallization.

From these facts it is quite evident that the optical rotation does not reveal the required information with all types of rosin.

Low Temperature Heat Treatment Method:

During this study another method which seemed to have possibilities presented itself. Its manipulation is even more simple than the determination of the optical rotation and involves the use of equipment which is always available in any chemical laboratory. For identification purposes this method has been designated the low-temperature heat treatment method and is conducted as follows:

Two hundred grams of rosin are placed into a 400-ml. beaker. The beaker with the rosin is then placed into a drying oven heated at a constant temperature of 100 to 105 C. and the time noted when crystals appear in the molten mass. With some rosins it is necessary to melt the rosin prior to placing it into the oven.

This test was conducted on the rosins listed in Table I and the following results were obtained:

Rosin No. 1.	Crystals appeared in 5 days
Rosin No. 2.	Crystals appeared in 15 days
Rosin No. 3.	Crystals appeared in 20 days
Rosin No. 4.	No crystals appeared in 30 days
Rosin No. 5.	Crystals appeared in 2 hours
Rosin No. 6.	Crystals appeared in 2 hours

It will be observed that the results of these tests follow quite regularly the crystallizing tendencies of the different types of rosin in oil solutions as shown in Table II. As a matter of fact, the exception, rosin No. 1, is not as pronounced as in the case of the optical rotation, which fact indicated that this rosin would be as permanently soluble as rosins Nos. 3 and 4, whereas it is not. The real exception in this test appears to be rosin No. 2. The results indicate that this rosin will not crystallize from oil solutions much more rapidly than rosin No. 3 and not nearly as quickly as rosin No. 1. The reverse, however, is the case, for, on referring to Table II, it will be observed that rosin No. 2 in solution in linseed oil at a rosin concentration of 30 per cent began crystallizing in 1 month, while rosin No. 1 at a rosin concentration of 35 per cent showed no crystals in 3 months.

This low-temperature heat treatment test was also conducted on a rosin which had previously been treated with 1.5 per cent of lime (calcium hydrate) and no crystals appeared in 30 days. These results indicate that this type of rosin is as stable in oil solutions as rosin No. 4, but in linseed oil at a rosin concentration of 50 per cent, crystals appeared in 10 days.

It is evident, therefore, that this test, as well as the optical rotation, is not applicable to rosin which has been partially neutralized with certain inorganic salts.

In summarizing the data herein contained, the optical rotation and the low-temperature heat treatment test each reveal certain valuable information, but without further tests, analyses or knowledge as to the origin and type of rosin, the results obtained with either or both are not sufficient to predict with a real degree of accuracy whether or not a rosin will crystallize from solutions having rosin concentrations ranging from 35 to 50 per cent.

During the investigation a number of discrepancies were noted in the results obtained in different experiments with the rosin solutions; that is, with identical solutions, but not necessarily prepared and stored under exactly the same conditions, the time required for crystallization was quite different. It is believed, however, that the results recorded in Table II are reasonably accurate as all of the solutions were prepared and stored under identical conditions.

Conclusions:

From the facts herein contained, it is evident that neither the optical rotation method nor the low-temperature heat treatment method reveals the required information to predict correctly and definitely what the crystallization tendencies of a rosin might be. The committee, therefore, cannot recommend either method for this purpose.

The solution method apparently does reveal the necessary facts, but owing to the time involved in its present form, it has no practical or commercial value. It does seem, however, that if some means could be devised whereby the crystallization could be accelerated, it would have possibilities. It is the suggestion of this committee that if any further work is to be done on the subject, it should be conducted along these lines. Also, that since the solution method offers the only means of control, the procedure as outlined in this report should be further investigated for the purpose of standardization and accuracy before other methods are studied.

Respectfully submitted on behalf of the subcommittee,

E. V. ROMAINE,
Chairman.

REPORT OF COMMITTEE D-19
ON
WATER FOR INDUSTRIAL USES

For a number of years, the Society has been represented on the Joint Research Committee on Boiler Feed Water Studies by Mr. Max Hecht and Mr. F. N. Speller. The work of this Joint Committee indicated the desirability of organizing a standing committee in the Society to formulate standard methods of water analysis for industrial uses. Committee D-19 was accordingly organized in 1932; in January, 1933, a meeting of the Temporary Advisory Committee was held in Pittsburgh, Pa., at which permanent organization was effected, Mr. Max Hecht being elected chairman of the committee. The scope of Committee D-19 is as follows:

> The study of water used for industrial purposes to include methods of sampling and analysis, classification and specification, water being considered as an engineering material. In addition to the standardization of methods, the purpose includes terminology and the interpretation of results of tests.

No meetings of Committee D-19 or its subcommittees were held during the past year. The committee has under active consideration the formation of a new subcommittee, the purpose of which is to prepare specifications for and methods of testing water conditioning chemicals and materials. One of the items on which active work may be started will be that of specifications and methods of test for zeolites.

Permanent organization of the subcommittees of Committee D-19 was made during the year and a detailed statement of their scope and activities appeared in the December, 1933, issue of the A.S.T.M. Bulletin.

Activities of Subcommittees

Subcommittee II, Editorial (E. P. Partridge, chairman).—An outline, defining the functions of this subcommittee, offering general suggestions for the description of test methods, and making specific recommendations concerning the treatment of the subjects of dissolved oxygen, carbon dioxide, and hydrogen-ion concentration, was circulated to the membership of Committee D-19 under date of January 12, 1933. Comments subsequently received from several members have been reserved for discussion until after the actual submission of test methods for consideration.

A paper by M. C. Schwartz and W. B. Gurney on "The Determination of Traces of Dissolved Oxygen by the Winkler Method"[1] was reviewed by this subcommittee and recommended for presentation at the annual meeting of the Society in June. The presentation of this paper will point to the useful need of standardization, particularly with reference to water in its relation to the corrosion of metals.

Subcommittee III on Methods of Sampling (R. E. Hall, chairman).—The work of this subcommittee has been divided into a number of sections, and representatives from the various fields have been requested to cooperate in furnishing data for a general survey of methods of sampling. The assembly of the various methods will be made prior to submission to the members of the subcommittee for approval.

Subcommittee IV on Methods of Testing (C. H. Fellows, chairman).—This subcommittee has been assembling methods of testing for the ions commonly found in water, and because of the detailed study required, progress has been necessarily slow. When the various reports are submitted, they will be assembled with a view to the preparation of test methods.

The chairman of this subcommittee acts in a similar capacity on Subcommittee VIII of the Joint Research Committee on Boiler Feed Water Studies. The latter committee has completed the preparation of methods of test for quantitative determination of sulfate, phosphate, carbonate, and hydroxide ions in boiler and boiler feed waters. These methods are now available to Subcommittee IV for study, subject to a future authorization from the Joint Research Committee, of which Mr. S. T. Powell is chairman.

The election of officers for the ensuing term of two years resulted in the re-election of Max Hecht as chairman and in the selection of R. E. Hall as temporary secretary.

This report has been submitted to letter ballot of the committee, which consists of 21 members; 18 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

MAX HECHT,
Chairman.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part II, p. 796 (1934).

REPORT OF COMMITTEE E-1
ON
METHODS OF TESTING

The work of Committee E-1 on Methods of Testing during the past year has largely been concentrated in its various technical committees which have been quite active. The progress made by these groups is recorded later in this report. The committee has continued its review of new methods of testing under consideration in the individual standing committees. This review has resulted in suggestions for improvement which have been brought to the attention of the committees concerned. While the committee has not met since the meeting at Chicago, Ill., in June, 1933, a number of meetings of subcommittees have been held. A meeting of the committee will be held at this annual meeting subsequent to the presentation of this report to the Society.

The organization of the new Section on Flexure Testing has now been completed with the following personnel:

H. F. Clemmer, *Chairman*, District of Columbia Engineer Dept.
G. W. Colton, Yale University
J. T. MacKenzie, American Cast Iron Pipe Co.
John Tucker, Jr., National Bureau of Standards
D. E. Parsons (representing Committee C-3 on Brick)
L. J. Trostel (representing Committee C-8 on Refractories)
A. T. Goldbeck (representing Committee C-9 on Concrete and Concrete Aggregates)
C. K. Roos (representing Committee C-11 on Gypsum)
D. W. Kessler (representing Committee C-18 on Natural Building Stones)
H. F. Clemmer (representing Committee D-4 on Road and Paving Materials)
M. O. Withey (representing Committee D-7 on Timber)
T. Smith Taylor (representing Committee D-9 on Electrical Insulating Materials)

A special committee or conference group has been appointed consisting of representatives of Committee E-10 on Standards and Committee E-1 to give consideration to methods of designating chemical, physical and similar specification requirements in the standards of the Society, and particularly to the significance of permissible variations prescribed for these requirements.

Subsequent to the 1933 annual meeting, as mentioned in the annual report last year,[1] on the recommendation of the Technical Committee on Mechanical Testing, Committee E-1 presented to the Society through Committee E-10 on Standards new Tentative Methods of Impact Testing of Metallic Materials (E 23 – 33 T) and revised Tentative Methods of Rockwell Hardness Testing of Metallic Materials (E 18 – 33 T). The new and revised methods were accepted for publication as tentative[2] by Committee E-10 at a meeting held on August 16, 1933, and appear in the 1933 *Proceedings*.[3]

Committee E-1 has recognized for some time that there is a community of interest among several of the standing committees of the Society in the methods of test for softening point (ring-and-ball and cube-in-water methods) of bituminous materials. A meeting of the representatives of the interested committees, arranged by the Technical Committee on Consistency, Plasticity, Etc., was accordingly held at Washington, D. C., on March 8, 1934, at the time of the spring group meetings of A.S.T.M. committees. In view of the widespread use of this test, particularly the ring-and-ball method, it was decided that an attempt should be made to review broadly the existing method, looking toward the possibility of improving the accuracy and detailed procedure of the test for softening point and at the same time enlarging the scope of the method. A special committee consisting of H. M. Hancock, chairman, C. E. Kinney, E. O. Rhodes and T. Smith Taylor was accordingly appointed to undertake the necessary studies.

Technical Committee on Mechanical Testing (H. F. Moore, chairman):

The change in organization of the Technical Committee on Mechanical Testing, the membership of which now consists of the chairmen of the sections, has worked satisfactorily and has materially facilitated the work of the committee. As recorded below, the technical committee has through the activities of its sections advanced the tension methods to standard, revised the Rockwell hardness test and issued new impact methods for metallic materials. The former standard for calibration of testing machines has been withdrawn in view of recent extensive developments in apparatus and replaced by new tentative methods. One new section, that on flexure testing, has been organized during the year.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 444 (1933).

[2] In submitting these tentative methods to Committee E-10 on Standards, the committee reported the following results of the letter ballot vote of a total of 50 ballots returned from a committee membership of 59: Tentative Methods of Impact Testing of Metallic Materials (E 23 – 33 T), 36 affirmative and 1 negative; Tentative Methods of Rockwell Hardness Testing of Metallic Materials (E 18 – 33 T), 39 affirmative and none negative.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, pp. 976 and 967 (1933); also 1933 Book of A.S.T.M. Tentative Standards, pp. 1010 and 1001.

Section on Tension Testing (R. L. Templin, chairman).—This section held a meeting on March 6, 1934, in connection with the group meetings of A.S.T.M. committees in Washington, D. C. Various phases of the standards for tension testing adopted last June were discussed, and certain criticisms of the methods of determining yield strength were considered at some length. It was specifically pointed out that the "dividers" method for yield strength or yield point was not suitable for use on an 8-in. gage length, while it was fairly satisfactory for some metals on a 2-in. gage length. It is recognized that the work of the section is interrelated with that of the Section on Elastic Strength of Materials, the Section on Testing Thin Sheet Metals, the Section on Effect of Speed of Testing and the committees of the Society, and arrangements are being made to keep in contact with these committees. The Methods of Tension Testing of Metallic Materials (E 8 - 33), prepared by this section, have been adopted as standard, and the committee is now in a position to go forward with tension test methods for other materials.

Section on Compression Testing (M. F. Sayre, chairman).—The section has been giving attention to the Tentative Methods of Compression Testing of Metallic Materials (E 9 - 33 T). It feels there is necessity for further revision, but that such revision is largely tied up with the work of the Section on Effect of Speed of Testing. The section is giving attention to this problem, as well as to problems of compression tests for other than metallic materials.

Section on Bend Tests for Ductility (A. B. Kinzel, chairman).—The free bend test is covered by the Tentative Method of Bend Testing for Ductility of Metals (E 16 - 31 T) which seems to be adequate for the purpose and free from objectionable features. It has been broadly adopted by the A.S.M.E. Boiler Code Committee, and by various insurance companies. A survey of the relations of the Bend Test Section with various standing committees of the Society is now in progress. This survey is for the purpose of procuring further opinion regarding the tentative method and of the desirability of adopting it as standard.

The matter of bend tests of thin sheets has given the committee some concern. No satisfactory bend test has been developed for such material, and in connection with a general survey of the subject, tests are under way to establish the order of magnitude of the probable error and the sensitivity of cup testing methods. An initial series of 300 cupping tests made by various laboratories on properly selected material failed to give the desired data, and in the past year this series has been almost entirely repeated. Correlation of the data on the second series is now under way, and it is hoped to be able to present during the coming year a report on the precision to be expected in cupping tests.

Section on Indentation Hardness (J. R. Townsend, chairman).—The Tentative Methods of Rockwell Hardness Testing of Metallic Materials (E 18 – 33 T) have been issued in their revised form for a year and the committee has been receiving comment upon them. So far no changes in these tentative methods are proposed, but it is thought that they had best remain tentative for another year. The section has discussed the question of standardizing size of balls and of loads for Brinell hardness tests of soft metals, but has no recommendations to make at present.

Section on Testing Thin Sheet Metals (C. H. Marshall, chairman).—In June, 1933, this section sponsored a round-table discussion on the use of the tension test for judging the suitability of sheet metal. A copy of the principal discussion presented at this meeting is submitted as an Appendix to this report.

The section is now actively at work collecting data on the different kinds of sheet metals and the usefulness of these tests. During the year the membership has been increased to include members from various committees of the Society. The section is working in cooperation with the Section on Indentation Hardness on the problem of hardness determinations for sheet metal, and with the Section on Bend Tests for Ductility.

Section on Flexure Testing (H. F. Clemmer, chairman).—This section has just been organized under the chairmanship of H. F. Clemmer, Engineer of Tests, Department of Highways, District of Columbia. Eight of the standing committees of the Society have appointed representatives and three representatives at large have been appointed. The committees that have appointed representatives are in the field of non-metallic materials while the members at large represent concrete and cast iron. The personnel is given earlier in this report.

Section on Impact Testing (W. W. Werring, chairman).—During the past year the Tentative Methods of Impact Testing of Metallic Materials (E 23 – 33 T)[1] were accepted by the Society as tentative. These methods cover the detailed procedure for operating, adjusting, and calibrating machines of both the Charpy and the Izod types. A valuable feature of the methods is an appendix listing the fields in which the notched-bar impact test has proved useful as an acceptance test for metals, and giving some critical discussion of the significance of the impact test, and some suggestions as to its proper interpretation. These methods are to be continued as tentative for another year before the question of their adoption as standard is considered.

---

[1] A revision of the Tentative Methods E 23 was presented to Committee E-10 on Standards subsequent to the annual meeting, see Editorial Note, p. 562.—ED.

Section on Effect of Speed of Testing (P. G. McVetty, chairman).—A meeting of this section was held in Pittsburgh, Pa., on April 16, 1934. The section faces a very difficult problem. It has become evident that the common method of measuring the speed of testing by the speed of head of testing machine is not an effective method for most materials of construction. Quite possibly rubber, and perhaps also textiles, form an exception to this statement. Steps are being taken to cooperate with the committees of the Society especially interested in this problem. So far the study of effect of speed has usually been confined to tension testing, but it is probable that it is at least equally important in the case of compression tests.

Section on Calibration of Testing Machines and Apparatus (H. F. Moore, chairman).—This section has prepared the following revisions of the Tentative Methods of Verification of Testing Machines (E 4 – 33 T) which, after approval by Committee E-1, are to be submitted to Committee E-10 on Standards so that the methods may be published in their revised form during the year:[1]

Section 13.—Change Paragraph (*a*) to read as follows by the addition of the italicized figure and the omission of the words and figures in brackets:

> 13. (*a*) The scale of the indicating mechanism shall be uniformly graduated. The distance between any two graduation lines, dots, or other dividing marks shall be not less than [0.04] *0.035* in. [nor more than 0.10 in. The width of the graduation lines, dots, or other dividing marks shall not be more than one fifth of the distance between them. The width of the index line or lines shall not exceed the width of the graduation lines on the scale. This requirement for width of index lines cannot be applied to devices in which the reading is taken from the position of the end of a fluid column along a scale on a glass tube, and this section shall not be interpreted as barring the use of such instruments.]

Section 16.—Change to read as follows by the omission of the words and figures in brackets:

> 16. Before taking readings for the formal verification of an elastic calibration device by means of dead weights or other primary standards, the device shall be subjected to a series of cyclic loads varying from a minimum load not greater than 2 per cent of the capacity load of the device to a maximum load not less than 5 per cent nor more than 10 per cent above the nominal capacity load. [This cycle of loading shall be repeated until either (*1*) the instrument reading for the corresponding extreme loads of two successive cycles shall not differ by more than one tenth of 1 per cent of the reading for capacity load, or (*2*) it becomes evident that the difference between readings for successive cycles is not diminishing, in which case the device is not to be approved for use in calibrating testing machines.]

---

[1] See Editorial Note, p. 562.—ED.

Section 17.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

17. To minimize errors due to temperature effect of stress and [those due to] psuedo-elastic action, the time schedule followed when verifying an elastic [calibration] device [should be reported, especially in the case of an elastic calibration bar] which is loaded in axial tension or compression *shall be reported;* and [approximately] the same time schedule, *within limits stated in the report,* [should] *shall* be followed when using the device to calibrate a testing machine.

Section 27.—Add a new note to this section as Note 2 to read as follows, numbering the present note as Note 1:

Note 2.—In no case shall the loading range be stated as including loads below a value which is 100 times the smallest load that can be read on the testing machine. (This means that if a testing machine has graduations so spaced that it can be read to within $\frac{1}{10}$ division and the machine is sensitive to $\frac{1}{10}$ division it would be possible for the loading range to extend down to the load corresponding to 10 divisions. On the other hand, if the testing machine was sensitive to only two divisions the loading range could not extend below the load corresponding to 200 divisions.)

Technical Committee on Consistency, Plasticity, Etc. (E. C. Bingham, chairman):

This committee has continued to work on the program submitted to it. Proposed definitions for consistency and plasticity were published in the 1933 annual report as information for the purpose of obtaining constructive suggestions and criticisms. The committee now proposes to submit these definitions in the form appended hereto[1] to Committee E-1 for approval at its approaching meeting to be presented later to the Society for acceptance as tentative through Committee E-10 on Standards.[2]

The chairman of the technical committee with Dr. Heinrich Hencky is working on a plan for correlation of different tests now before the Society for viscous and plastic flow, attempting to obtain a means for simple measurement of these quantities in absolute units.

As mentioned earlier in this report, a special committee has been appointed to undertake a study of the softening point test (ring-and-ball method). It is expected that this work will result in improvement in the apparatus and methods and that the test will be more generally applicable.

Technical Committee on Particle Size and Shape (L. T. Work, chairman):

The work of this technical committee during the past year has been centered in the activities of its Sections on Fine Sieves and on Sub-Sieve Sizes, as reported below:

---

[1] See p. 1245.—Ed.

[2] See Editorial Note, p. 562.—Ed.

Section on Fine Sieves (A. A. Klein, chairman).—This section has reviewed the Tentative Method of Test for Particle Size of Ground Refractory Materials (C 92 - 32 T), prepared by Committee C-8 on Refractories. This resulted in a number of constructive suggestions for improvement of the method and these have been brought to the attention of Committee C-8 for consideration. This section still has before it the subject of better screens and sieving methods on which it is hoped progress may soon be reported. The chairman has under consideration work on precision punched screens.

Section on Sub-Sieve Sizes (G. S. Haslam, chairman).—This section has under way a cooperative test program for developing the count method of particle size measurement. These studies are being carried on by a group of seven laboratories and an attempt is being made to correlate particle size test data obtained by the count method. The program has been arranged under the direction of Mr. R. P. Allen. Calibration of the microscopes used in the various laboratories and preparation of the samples to be used in the cooperative tests were first undertaken, but due to unavoidable and unforeseen difficulties this preliminary work was considerably delayed. The work, however, is now progressing satisfactorily.

Of interest in connection with the work of this section is a paper presented at this annual meeting by H. H. Hatch on "The Importance and the Determination of Particle Sizes of Hydraulic-Fill Dam Materials,"[1] which was also presented at the Round-Table Discussion on Industrial Applications of Particle Size Measurements, sponsored by the committee in March, 1933.

Technical Committee on Chemical Composition (G. E. F. Lundell, chairman):

The personnel of this technical committee has recently been enlarged to include a number of advisory members who are actively engaged in chemical analysis work and are accordingly especially qualified to review the detailed analytical chemical procedures developed by the various standing committees of the Society. The technical committee has through its chairman reviewed the following three new tentative chemical methods during the past year and in each case constructive suggestions were made to the standing committee which developed the methods:

Tentative Methods for the Determination of Aluminum and Titanium in Nickel-Chromium and in Iron-Nickel-Chromium Alloys prepared by Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys;

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part II, p. 739 (1934).

Tentative Methods of Chemical Analysis of Magnesite Refractories, prepared by Committee C-8 on Refractories, and

Tentative Methods of Test for Small Amounts of Copper and Manganese in Textiles (D 377 - 33 T), prepared by Committee D-13 on Textile Materials.

Methods dealing with the "Unificazione Dei Metodi Di Analisi Degli Accai Semplici E Delle Ghise Communi" which had been submitted to the Society by Uni Ente Nazionale per l'Unificazione Nell'Industria, Milan, Italy, were also reviewed by the technical committee and found to pattern very closely after the methods of the A.S.T.M.

As to future activities, it is recommended that all standing committees of the Society should review their methods of chemical analysis that are over 10 years old and revise them in accordance with recent advances that have been made in analytical chemical procedure. Subcommittee XII on Chemical Analysis of Committee A-1 on Steel is about to undertake a thorough revision of the A.S.T.M. Standard Methods for Chemical Analysis of Plain Carbon Steel (A 33 - 24) and of Alloy Steels (A 55 - 24).

Technical Committee on Thickness Measurement (W. E. Emley, chairman):

One meeting was held during the year by this technical committee at which the various methods of measuring thickness were again called to the attention of the members. It was decided to communicate with the chairmen of Committees D-11 on Rubber Products and D-13 on Textile Materials to see if arrangements could be made whereby only one method might be specified for measuring the thickness of all rubber products and one method for measuring the thickness of all textiles. This has been done and the chairmen of these committees were found to be sympathetic toward such a movement. In Committee D-13 the matter has been referred to an appropriate subcommittee.

Technical Committee on Interpretation and Presentation of Data (Anson Hayes, chairman):

During the past two years the technical committee has been urged on several occasions to bring before the general membership a practical exposition of some of the simpler ways and means of applying statistical methods and quality control theory to problems of sampling and interpretation of data in A.S.T.M. work. The efforts of the committee during the past year have, to a large extent, been directed to this end.

One of the sessions of this annual meeting is under the auspices of the technical committee, and will be devoted to the subject of, "Some Aspects of Specifying and Controlling Quality." Two papers are to be presented, one by Mr. H. F. Dodge on, "Acceptance-Rejection Requirements in Specifications,"[1] and the other by Mr. W. C. Chancellor on, "Application of Statistical Methods to the Solution of Metallurgical Problems in the Steel Plant."[2] The first paper discusses certain sampling clauses that are sometimes incorporated in specifications where quality can be measured only by sampling. It indicates that statistical control of quality of product from any source may be an important factor in determining how much consumer testing may be needed in a particular instance. In this connection, the second paper outlines some of the advantages, from the standpoint of both the consumer and the producer, of setting up a quality control program in a manufacturing plant. Both papers indicate ways in which statistical methods are being employed to advantage in these problems.

At a meeting held on March 6, 1934, the committee was requested to consider the feasibility of preparing additional material relating to statistical methods of handling data, somewhat along the lines used in preparing the committee's Manual on Presentation of Data.

During the year the technical committee has cooperated with several other committees of the Society on specific problems of presentation of data. The committee has also offered to cooperate with authors preparing papers for presentation before the Society in the study of their data in order that they may be presented most effectively.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee, which consists of 58 members; 42 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

W. H. FULWEILER,
Chairman.

R. E. HESS,
Ex-Officio Secretary.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part II, p. 877 (1934).

[2] *Ibid.*, p. 891.

EDITORIAL NOTE

Recommendations to Committee E-10 on Standards.—Subsequent to the annual meeting Committee E-1 on Methods of Testing presented to the Society through Committee E-10 on Standards the following recommendations which were accepted by Committee E-10:

Proposed Tentative Definitions of the Terms Consistency and Plasticity were accepted on August 22, 1934, for publication as tentative and appear on page **1245**.

Revisions of the Tentative Methods of Verification of Testing Machines were accepted on August 22, 1934, and the methods in their revised form appear on page 1233.

Revisions of the Tentative Methods of Impact Testing of Metallic Materials were accepted on November 15, 1934, and the methods in their revised form appear on page 1201.

APPENDIX

DISCUSSION ON USE OF THE TENSION TEST FOR JUDGING THE SUITABILITY OF SHEET METALS FOR VARIOUS PURPOSES

The Section on Testing Thin Sheet Metals of Committee E-1 on Methods of Testing has under consideration problems dealing with the various methods and tests used for metals in sheet form. A special subcommittee was assigned the study of the use of the tension test for judging the suitability of sheet metals for various purposes. To encourage the informal presentation of information concerning the practical utilization of the tension test for metals in sheet form the committee arranged for a round-table discussion on the subject, which was held on June 27, 1933, in Chicago, Ill., during the 1933 annual meeting of the Society. This meeting provided an excellent opportunity for the exchanging of ideas and experiences by both sheet manufacturers and users for the purpose of increasing the general fund of knowledge on the tension testing of sheet materials.

Written Discussion

The following discussions were presented in writing at the meeting:

R. L. Kenyon.[1]—The tension test is generally considered as measuring one of the fundamental properties of matter, namely, tensile strength. Because of this fact, together with the comparative simplicity of the test procedure, it has become one of the most widely used physical tests. Although specially prepared specimens are required, this disadvantage is somewhat offset by the fact that several other material constants can be determined in the course of the test.

While the test appears at first to be very simple, closer study reveals many complicating factors. Many articles have been published on the effect of these various factors and there is at least one book(**1**)[2] completely devoted to the subject of "The Tensile Test." Sachs, the author of this book, says in the introduction, "there is a wide gap between the carrying out of the tension test and the establishment of its true meaning and the value of the numerical results obtained. . . . the absolute magnitude of the values determined depends to a large extent on the form of the specimen and the conditions of the test." These points are mentioned by way of introduction; it should be said, however, that our problem is not concerned with the method of tension testing of sheet materials, but with the interpretation of the results. The question may be stated thus: In what way is the tension test being used today to determine the suitability of sheet material for various purposes?

---

[1] Supervising Research Engineer, The American Rolling Mill Co., Middletown, Ohio.

[2] The boldface numbers in parentheses refer to the papers given in the accompanying list of references on p. 569.

Let us first consider some specifications in which tensile properties are included. For example, the Tentative Specifications for Aluminum Sheet and Plate (A.S.T.M. Designation: B 25 – 34 T)[1] cover four tempers of material and specify minimum tensile strength and minimum elongation for each. The Standard Specifications for Sheet High Brass (A.S.T.M. Designation: B 36)[2] specify minimum and maximum tensile strength on two grades. The Tentative Specifications for Magnesium-Base Alloy Sheet (A.S.T.M. Designation: B 90 – 34 T)[3] specify minimum tensile strength and percentage elongation on two grades.

J. B. Johnson(2) gives the tension requirements of sheet materials for aeronautical purposes. The materials mentioned include several steels, stainless steel, copper, brass, bronze, Monel metal, and aluminum. In all cases, it is apparent that the principal consideration is strength with secondary emphasis on ductility; in other words, the sheets are being considered as parts of structures and the strength is foremost in importance.

From the examples just cited, it would appear that actual use of the tension test for inspection purposes on sheet metal seems to be limited to those applications in which mechanical strength is requisite as in aeronautical construction.

There has been a tendency in recent years to write specifications for physical properties of sheets for deep-drawing purposes. The chief difficulty in this connection has been lack of agreement as to the reliability of any present-day test to indicate accurately when a given lot of material would or would not be suitable for a given drawing job. This is the reason that sheet manufacturers will not guarantee to meet both physical specifications and performance requirements.

Winlock and Kelley(6) in 1927 published the results of their attempts to correlate drawing performance and mechanical properties of auto body sheet steel. They state "of all the different methods of testing and correlation of the different properties obtained by the methods used, experience showed that the percentage elongation as obtained in the ordinary tension test gives the most reliable indication of the deep-drawing properties of sheet steel, and further that this property is of greatest value when obtained in directions both parallel and transverse to the direction of final rolling. . . . It was found . . . . that the most difficult stampings were made successfully when the minimum elongation in the 8-in. gage length of test pieces taken parallel to the direction of rolling was 25.0 per cent and when, at the same time, the elongation in test pieces taken transverse to the direction of rolling was 25.0 per cent." Furthermore, they state, "The ratio of yield point to tensile strength is considered by many to be of value in determining the ductility of sheet steel. In our experience we have found good drawing qualities in materials in which this ratio differed widely. In general, the more nearly the yield point approaches 50 per cent or less of the tensile strength, the less is the tendency to form buckles which are difficult to draw out, but on the other hand excellent stampings of difficult design can be made when the yield point is more than 65 per cent of the tensile strength. It thus appears that the yield point – tensile strength ratio is not very helpful."

---

[1] See p. 605.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 728.

[3] See p. 688.

W. H. Graves(3) in 1930 reported that his experiments indicated "that for extra-deep drawn (auto body) parts the elastic limit must not exceed one half the tensile strength." Apparently this refers to box annealed material because normalized and box annealed sheets always have elastic ratios higher than this.

E. S. Lawrence(4) in 1931 stated that he knew "of a number of cases where extremely difficult body stampings were produced with less breakage from a normalized strip steel where the elastic limit was approximately 70 per cent of the ultimate strength, whereas, conventional sheet steel of the same carbon content showed greater breakage, even though it was normalized and box annealed and even had the same chemical analysis. The apparent and marked difference indicated that the sheet steel had an elastic limit of only 60 to 65 per cent of its ultimate strength, whereas, the elastic limit of the strip was approximately 10 per cent higher."

Eisenkolb(5) made both Erichsen and tension tests on mild steel deep-drawing sheets and found the latter to "enable comparison of different kinds of sheets" in respect to drawing performance. He points out, however, "that flow conditions as they occur in the fracture of test specimens are different from those occurring in the drawing operation in the press. In the test specimen, the flow is unimpeded, following only the tensile forces, whereas, in the press the flow is forced under the lateral pressure of the hold down and the adjacent parts."

Vietorisz(7) in 1930 presented in English for the first time some theoretical quantities derived from the tension test and stress-strain curve. As far as is known, none of these have been actually used in determining the suitability of sheets for specific purposes. All of the tests reported by Vietorisz were on heavy sections and not on sheets. One of the quantities which he measured, was the "uniform elongation" or the elongation up to the beginning of local contraction. We applied all of Vietorisz' criteria to two lots of sheet material, one of which drew and one did not on a certain job. There was no significant difference between the results of the tests on the two lots in respect to any of the quantities described by Vietorisz.

Kenyon(8) in 1932 presented data on the "uniform elongation" on sheet samples and showed how to determine it from accurately drawn stress-strain curves. He suggested its probable usefulness as a measure of drawing quality, but made no correlations. Kenyon and Burns(9) in the same year described an accurate method of obtaining stress-strain curves of sheets and showed the correlation between certain characteristics of the curves and "stretcher-strains." They showed a quantitative relationship between yield point elongation and severity of stretcher-strains.

E. V. Crane(10) in a number of publications has advocated the use of a true-stress curve, derived from the autographic stress-strain curve, for determining the rate of strain-hardening and the capacity of the material for further cold work. He presents sample calculations of determinations of amount of draw possible between intermediate annealing, etc. Kenyon and Burns(9) have questioned the significance of the true-stress curve as a measure of rate of strain-hardening.

In 1924, H. M. Williams(11) discussed requirements of deep drawing sheets for automobile bodies. He said "Very great losses in unusable stampings and in labor to repair defective ones have resulted from faulty or unsuitable material, difficult forms, and improper die construction. Frequently a new die will not produce a perfect stamping for weeks after it is put in commission. Body engineers design parts that are very difficult to develop and the die engineer is not consulted until the design has been approved. It is then a question of finding a quality of sheet that will produce the desired part in a certain die; which often makes it necessary for some sheet mill to produce a new quality sheet."

"In order to establish a standard nomenclature for automobile sheet steels, the General Motors Corporation has adopted a tentative specification based on finish and suitability for forming certain classes of parts. This specification is drawn up with the full cooperation of the sheet mills and represents as full a knowledge as we now have. It will be noted that no attempt has been made to determine temper and forming quality, as no reliable method is as yet available."

These statements written in 1924 apply to the situation in 1933.

The tension test has been used also to measure or indicate the directional properties of sheet metals. Phillips and Samans**(12)** used it for cold-rolled and annealed commercial bronze; Phillips and Bunn**(13)** for cold-rolled and annealed copper; Mathewson, Trewin, and Finkeldey**(14)** for soft-rolled strip zinc; Price and Davidson**(15)** for cold-rolled brass. The procedure, in general, is to make tension tests on specimens cut from the sheet at various angles relative to the direction of rolling. Variation in percentage elongation has been found to correlate with "earing" on cup-shaped draws.

Straw, Fischupp and Helfrich **(16)** have presented valuable data on the forming properties of thin sheets of some non-ferrous metals.

The foregoing references are not intended to serve as a bibliography on the subject of tension testing of sheet materials. They are mentioned merely to indicate the trend of applications that have been published in the scientific literature. Most of the articles mentioned refer to the use of the test for determining drawing quality. There are, however, many other uses of sheets.

The purpose of this meeting is to discuss the use of the tension test for judging the suitability of sheet materials for *various* purposes. The remainder of the meeting is now open for the expression of ideas on this subject. We are not here to discuss methods of testing, but the interpretation of the results of the test.

J. R. TOWNSEND.[1]—The problem of the tension test and its application to engineering control of the quality of materials should be discussed not only from its fundamental standpoint but also with relation to the possibility of its controlling the quality required of raw material.

Tension tests are mainly applied to materials used for structural purposes and here it is essential to know the ultimate strength of the material. For many years tension tests have been made as a basis of acceptance or rejection of a variety of raw materials. The ultimate strength of materials is a basic requirement. The tension test, however, yields more information than merely the tensile strength. Besides this property it enables one to obtain the modulus of elasticity, elastic limit, proportional limit, yield stress, the true strength of the materials (load divided by cross-section at the moment of failure) and the percentage elongation. Essentially, the tension test consists in loading a specimen at a definite rate of loading, measuring the units of elongation with units of load, until the specimen fractures. The load-elongation curve thus produced can be used to measure the strength, the elastic range and the degree of ductility of the material. No matter for what purposes materials may be used in structures the properties of ultimate strength, elastic range and ductility are absolute essentials.

---

[1] General Development Laboratory, Bell Telephone Laboratories, New York City.

Hardness tests may be substituted for tension tests because they are easy to make and do not destroy the material. The most scientific method of making a hardness test by the use of an indenting tool is by the use of Myer's analysis of the Brinell test. In brief the Myer's analysis means:

$$P = ad^n$$

where P = the load;
a = a constant depending upon the ultimate strength of the material;
d = the diameter of the indentation, and
^{n} = the measure of the work hardening character of the material.

The constant, a, for cold-worked materials bears a straight line relationship to ultimate tensile strength. Here, again, where hardness is substituted for tensile strength the basis of the hardness test is in reality similar to the tension test, since it determines the permanent indentation made by a definite load upon a steel ball forced into the material under test, whereas, the tension test consists in determining the load required to produce rupture and ultimate deformation of the material.

One of the essential characteristics of a specification for material is that the producer and the consumer should have the necessary testing equipment available and understand the method of procedure. Tension testing machines are in universal use and their operation is well understood in that standard methods of tension testing have been nationally recognized for some years.

It may be argued that other forms of test would be more direct in measuring the quality of sheet metal, for example, a ductility test such as the Erichsen test, the reverse bend test such as the Amsler reverse bend test, a variety of hardness tests and more recently by a cantilever beam test which determines modulus of elasticity and yield point (Mueller test). The main thing that these tests have to recommend is that they appear to the engineer as being an end-point test, a test that is very similar to the use to which they are put in service or in manufacture. In general, such tests are regarded as quality controlling tests, but nevertheless it is the experience of all testing engineers that complete faith cannot be placed in them unless it can be shown that the data obtained by them can be correlated with the tension test or with the performance of the material in service or in fabrication. As examples, I might cite the series of papers[1] which lead up to the issuance of the Standard Specifications for Sheet High Brass (A.S.T.M. Designation: B 36) of the American Society for Testing Materials.[2] These papers deal with a careful study of all available methods of testing sheet non-ferrous metal and, whereas the Rockwell hardness test was adopted as a preliminary inspection test, the tension test was considered the basic test upon which the acceptance and the rejection of the material was based. Sheet brass, for example, is used for a variety of purposes and here the essential characteristics that are important are strength, hardness, wear resistance, spring properties, ductility and corrosion resistance. Experience has shown that if the chemical composition limits are met, either the hardness or tension test limits will adequately control wear, corrosion resistance, ductility, formability and a host of machining operations that must be performed upon the material. In other words, it is incompatible that sheet brass meeting the chemical, hardness, and tension tests would show any high degree of variability in any other properties.

---

[1] H. N. Van Deusen, L. I. Shaw and C. H. Davis, "Physical Properties and Methods of Test for Sheet Brass," *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part II, p. 173 (1927); C. H. Davis and E. L. Munson, "Hardness Relationships and Physical Properties of Some Copper Alloys"; also J. R. Townsend, W. A. Straw and C. H. Davis, "Physical Properties and Methods of Test for Some Sheet Non-Ferrous Metals," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part II, pp. 422, 381 (1929).

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 728.

Other sheet materials, for example, aluminum, can best be controlled by the tension test and chemical composition limits. No other forms of mechanical tests have as yet been developed for aluminum or aluminum alloys that are as satisfactory. In fact no other tests exist that are generally recognized in engineering practice.

In the case of steel, if the chemical composition, heat treatment, hardness, tensile strength and percentage elongation are stipulated the material is adequately controlled. To be certain, a ductility or forming bend test may yield some information of a practical character and the same is true of any other test that can be devised which relates to either the fabricating process or to use in service, but the essential information about the material is contained in the data on hardness, tensile strength, heat treatment, and chemical composition.

In addition to the considerations mentioned above the tension test has reproducibility to a higher degree than any other mechanical test known, and this is an essential character of a satisfactory inspection test.

To sum up, it is my opinion that further developments, involving refinement of the method of making tension tests both in methods of applying and measuring the load as well as refinement in methods of measuring elongation, are required. It is my belief that time would be more profitably spent in developing the tension test to a higher degree of efficiency than in developing other tests which in any case would only have a limited range of application.

Other forms of test may be developed and will have narrow fields of usefulness and materials may be specified according to these tests, but in any case the usefulness of these tests will be restricted. An example may be cited in the case of the Standard Specifications for Rolled Zinc (A.S.T.M. Designation: B 69), of the American Society for Testing Materials,[1] where the temper and the dynamic ductility tests are applied. These two tests seek and are successful in determining the formability and drawability of sheet zinc, two of the principal uses to which this material is put in manufacture. Whereas, these tests are entirely satisfactory in controlling the quality of sheet zinc that we desire, nevertheless their application is at present, and probably will be, entirely restricted to sheet zinc. It may be stated in passing that because of the peculiar characteristics of sheet zinc the tension test is difficult to apply because the rate of loading is very important with regard to the ultimate strength and the apparent elastic range. Under properly controlled conditions, however, there is no reason why the tension test could not be applied to sheet zinc with entire satisfaction.

It must be understood that the above remarks apply to static testing. When the material is used dynamically or under conditions of repeated stress, the fatigue test is absolutely essential. Here again, the mere determination of the endurance limit only is not all, but a careful determination of the stress-cycle curve from stresses equivalent to the ultimate strength to stresses less than the endurance limit.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 849.

DIGEST OF ORAL DISCUSSION

The following statements cover the main points brought out in the oral discussion:

Physical testing is far in advance of die design and it is the latter that really needs the greater amount of study. There is a need of cooperation between the die designers and sheet producers to avoid unreasonable demands on material for drawing purposes. There is a difference of opinion in regard to the suitability of cupping tests; some believed them to be better than tension tests for indicating drawability of sheets, and others believed them to be good only for stretching the surface in order to indicate the grain size. The tension test also stretches the surface and therefore gives an indication of grain size and furthermore gives a better opportunity to examine the fracture for laminations. Limits for drawability can be set by means of the tension test by testing all lots of material and correlating the results with the performance in drawing. The drawability of sheets is affected by other factors than those shown by the tension test. The surface and the grain structure must also be considered. The drawing performance of aluminum sheets was stated to be predictable from the tension test providing that the grain size, chemical analysis, and thickness were all kept constant.

In conclusion, the following summarizing statement was made:

The tension test is useful:

1. As an inspection tool;
2. As a basis for engineering design data;
3. As a basis for making changes in fabrication; and
4. As a basis for specifications.

In all cases it should be used in conjunction with chemical analyses, grain size, gage uniformity, and surface finish.

REFERENCES

(1) "Der Zugversuch," G. Sachs-G. Fiek, Akademische Verlagsgesellschaft, Leipzig (1926).

(2) J. B. Johnson, "Dependence of Aviation on Metallurgy," *Metals and Alloys*, April, 1930, p. 450.

(3) W. H. Graves, "Sheet Steels for Automobiles," Symposium on Developments in Automotive Materials, Detroit Regional Meeting, Am. Soc. Testing Mats., p. 18 (1930).

(4) E. S. Lawrence, "Comparison of Sheet and Strip Steels for Difficult Stampings," Preprint No. 11, Am. Soc. Steel Treating Convention (1931).

(5) Fritz Eisenkolb, "Testing the Deep Drawing Qualities of Thin Iron Plates," *Stahl und Eisen*, Vol. 52, p. 357 (1932); also *Metal Stampings*, November, 1932.

(6) J. H. Winlock and G. L. Kelley, "Testing Automobile Body Sheets," *Transactions*, Am. Soc. Steel Treating, Vol. 12, p. 635 (1927).

(7) Vietorisz, "The Malleability of Rolled Soft Steel and a New Method of Its Improvement," *Carnegie Scholarship Memoirs*, Vol. XIX, p. 167 (1930).

(8) R. L. Kenyon, "Per Cent Elongation in the Tensile Test as a Method of Measuring the Ductility of Thin Sheets," *Metals and Alloys*, pp. 220, 232 (1930).

(9) R. L. Kenyon and R. S. Burns, "Autographic Stress-Strain Curves of Deep Drawing Sheets," *Transactions*, Am. Soc. Steel Treating, Vol. 21, p. 577 (1933).

(10) E. V. Crane, "Strain Hardening of Plastic Metals During Cold Working in Power Presses," *The Iron Age*, July 23, August 20, September 3 and October 1, 1931.

(11) H. M. Williams, "Automobile Sheet Steel Specifications," *Transactions*, Am. Soc. Steel Treating, Vol. 5, p. 82 (1924).

(12) A. Phillips and C. H. Samans, "Directional Properties in Cold Rolled and Annealed Commercial Bronze," *Technical Publication No. 491*, Am. Inst. Mining and Metallurgical Engrs., October, 1932.

(13) A. Phillips and E. S. Bunn, "Directional Properties in Cold Rolled and Annealed Copper," *Technical Publication No. 413*, Am. Inst. Mining and Metallurgical Engrs., October, 1932.

(14) C. H. Mathewson, C. S. Trewin and W. H. Finkeldey, "Some Properties and Applications of Rolled Zinc Strip and Drawn Zinc Rod," *Transactions*, Am. Inst. Mining and Metallurgical Engrs., Vol. 64, p. 305 (1920).

(15) W. B. Price and P. Davidson, "Physical Tests on Common High Brass Taken Parallel and at Right Angles to the Direction of Rolling," *Transactions*, Am. Inst. Metals, Vol. 10, p. 133 (1916).

(16) W. A. Straw, C. R. Fischupp and M. D. Helfrich, "Forming Properties of Thin Sheets of Some Non-Ferrous Metals," paper presented before the Am. Inst. of Metals, February, 1931.

REPORT OF COMMITTEE E-4 ON METALLOGRAPHY

During the year, Committee E-4 held one meeting in Chicago, Ill., on June 29, 1933, and a meeting of Subcommittee I was held in Washington on March 8, 1934, during the Spring Group Meetings of A.S.T.M. Committees.

At the meeting in Chicago, a proposed new subcommittee to study the structure and grain size of tool steels was suggested. Another proposal was for a subcommittee to work out a recommended practice for dilatometric analysis. These matters are still under consideration with no definite committees formed.

The chairman of Subcommittee I on Selection and Preparation of Samples, Mr. E. H. Dix, Jr., has prepared a draft of the proposed revision of the Standard Methods of Metallographic Testing of Iron and Steel (E 3 – 24), and Methods of Metallographic Testing of Non-Ferrous Metals and Alloys (E 5 – 27). This review includes recommendations made in the "Preliminary Report on Metallographic Standards for Iron and Steel," prepared by Mr. Samuel Epstein.

Subcommittee IV on Photography (Leon Foster, chairman) is recommending the incorporation in the present Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (E 2 – 30)[1] of a method for obtaining a magnification of 25 diameters. The approved recommendation reads: "A photographic lens of 48 or 42 mm. focal length with ocular ×5, or of 32 mm. focal length with no ocular."

It is proposed at the next meeting of Committee E-4 to take formal action upon the table of magnifications now given with the view of having them incorporated in a revision of Table II of the present recommended practice for photography as applied to metallography:

MAGNIFICATION	OBJECTIVE	OCULAR
25×	48 or 42 mm.	5×
	32 mm.	None
50×	32 mm.	5, 6, or 7.5×
100×	16 mm.	5, 6, or 7.5×
250×[a]	8 mm.	5, 6, or 7.5×
500×	4 mm.	5, 6, or 7.5×

[a] Standard already adopted.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 900.

The election of officers for the ensuing term of two years resulted in the re-election of the present incumbents.

This report has been submitted to letter ballot of the committee which consists of 48 members; 41 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

C. H. DAVIS,
Chairman.

O. E. HARDER,
Secretary.

REPORT OF COMMITTEE E-6
ON
PAPERS AND PUBLICATIONS

The activities of Committee E-6 comprise the supervision of all publication matters including the development of the technical program for the annual meeting and the review of papers prior to their acceptance.

Program for 1934 Annual Meeting:

The committee presents what it believes to be a well-rounded program for the present annual meeting, with papers in many of the materials fields in which the Society is engaged, including cement and concrete, mortars, brick, corrosion and fatigue of metals, iron and steel, and testing. Several interesting discussions are in prospect, including a discussion on tinting strength and a discussion on vapor lock. Special attention should be called to the session on Some Aspects of Specifying and Controlling Quality, and to a paper by C. A. Hogentogler and E. A. Willis entitled "Subgrade Soil Testing Methods," which paper marks the initiation on the part of the Society of work in this important field.

A series of symposiums presenting data on various types of castings, held at the annual meetings during the past few years, is continued by the presentation of the report submitted by Committee B-7 on Light Metals and Alloys, Cast and Wrought, entitled "Service Characteristics of Light Metals and Alloys."

While it has not been possible to preprint everything for the meeting due partly to budget limitations and partly to the fact that some few reports and papers were received so late as not to leave adequate time for editing and publication, all but 24 reports and papers have been printed; this includes 4 informal or progress reports which it is not intended to publish.

As usual the preprints were distributed to the members in advance of the meeting in two installments and a third installment is being distributed during the week of the meeting. The following table gives statistical information on preprinting:

	Reports		Papers		Total	
	Number	Pages	Number	Pages	Number	Pages
Preprinted	36	680	34	400	70	1080
Not preprinted	10	180	10	232	20	412
	46	760	44	632	90	1492

Washington Regional Meeting:

The technical program for the fifth Regional Meeting of the Society held in Washington, D. C., on March 7, 1934, constituted a Symposium on the Outdoor Weathering of Metals and Metallic Coatings sponsored by the Society's Committees A-5 on Corrosion of Iron and Steel and B-3 on Corrosion of Non-Ferrous Metals and Alloys. The titles and authors of the five papers comprising the symposium are given below:

Outdoor Test Results on Bare and Metal-Coated Ferrous Specimens—C. D. Hocker.
The Harmony of Outdoor Weathering Tests—R. F. Passano.
The Influence of Rainfall and Smoke on the Corrosion of Iron and Steel—G. N. Schramm and E. S. Taylerson.
The Early Interpretation of Test Results in the Atmospheric Corrosion of Non-Ferrous Metals and Alloys—W. H. Finkeldey.
Galvanic Corrosion by Contact of Dissimilar Metals—C. L. Hippensteel.

The papers, together with the discussion, will be published in a separate volume.[1]

Regular Publications:

A summary of the principal publication activities during the year is given below:

Year Book—248 pp., 2500 copies.
1933 Book of Standards—Part I, 1022 pp., Part II, 1326 pp., 7000 copies.
1933 Book of Tentative Standards—1164 pp., 1400 copies.
Combined Index to Standards and Tentative Standards—124 pp., 10,000 copies.
Proceedings—Part I, 1104 pp., Part II, 810 pp., 3950 copies each part.
A.S.T.M. Bulletins (six issues), 100 pp., 5500 to 6300 copies.

Special Reprints:

In addition to the regular publications, Committee E-6 has supervised the publication of a number of special reprints and compilations of standards. These are listed below. Special attention is called to the reprints of the Edgar Marburg Lecture which were made available in an edition printed on coated stock in view of the many micrographs and other photographs contained. The reprints of the Symposium on Cast Iron also represent a publication of some magnitude.

Marburg Lecture—"Crystalline Structure in Relation to Failure of Metals—Especially by Fatigue," by Herbert John Gough, 115 pp., 1200 copies.
"Impact Testing of Cast Iron"—51 pp., 750 copies. This is a reprint from the report of Committee A-3 on Cast Iron and covers an extensive investigation on impact testing of cast iron.

---

[1] Symposium on the Outdoors Weathering of Metals and Metallic Coatings, Washington Regional Meeting, Am. Soc. Testing Mats. (1934).

Reprint of Report of Committee A-5 on Corrosion of Iron and Steel—36 pp., 500 copies first printing, 250 copies second printing.

✓Committee D-1 Compilation "A.S.T.M. Standards on Preservative Coatings for Structural Materials"—350 pp., 2500 copies.

Committee D-2 Compilation "A.S.T.M. Standards on Petroleum Products and Lubricants"—292 pp., 2400 copies.

Committee D-9 Compilation "A.S.T.M. Standards on Electrical Insulating Materials"—242 pp., 650 copies.

✓Committee D-13 Compilation "A.S.T.M. Standards on Textile Materials"—164 pp., 1600 copies.

Committee E-1 Manual on Presentation of Data—45 pp., 1000 copies first printing, 1500 copies second printing.

Symposium on Cast Iron—172 pp., 3000 copies. Of the 3000 copies printed, 100 were bound in cloth, the rest in heavy paper binding; 1000 copies in paper and 50 in cloth binding have been furnished to the American Foundrymen's Association.

Special Publication:

Symposium on Motor Lubricants—121 pp., 2000 copies. This volume, containing the papers and discussion presented at the New York Regional Meeting in March, 1933, is available in both cloth and paper binding.

Papers Presented at Meeting of Committee D-13:

The following papers have been reported to the Papers Committee as having been presented at the October and March meetings of Committee D-13 on Textile Materials:

Strain Measurements of the Band Ply of an Inflated, Loaded Pneumatic Tire—H. W. Buckwalter.

An Improved Method for Converting an Observed Skein Strength to That for a Specified Count—M. E. Campbell.

Recent Developments in Testing Apparatus—Alfred Suter.

Demonstrations of New Method of Determining Single Ply and Cable Twists as They Lay in the Cord—J. M. Scott.

Sanforizing—H. D. Clayton.

A Method of Analyzing Cotton Yarn Strength Data—M. E. Campbell.

Discussion of Statistical Analysis as Applied to Tire Fabric Testing—W. R. Marsden.

The Relation of Tensile Strength to Rate of Load—D. C. Scott.

The Problem of Character in Raw Cotton—C. M. Conrad.

The Importance of Cooperation Between the Cotton Textile Industry and the Cotton Breeder—D. R. Coker.

Determinations of Fineness and Maturity of Cotton Fibers—T. L. W. Bailey, Jr.

Improvements in the Chandler Bundle Method for Measuring Strength of Cotton Fibers—H. R. Richardson.

Respectfully submitted on behalf of the committee,

C. L. WARWICK,
Chairman.

REPORT OF COMMITTEE E-8
ON
NOMENCLATURE AND DEFINITIONS

Since relatively few definitions have required final action on the part of Committee E-8, no meeting of the committee has been deemed justified during the year, action on the definitions having been handled by correspondence. A meeting of the Editorial Committee, however, has been held to review the various tentative definitions now before the committee and various suggestions have been transmitted to the standing committees concerned. A report of the Subcommittee on Definitions of the Terms Net and Gross Calorific Values, under the chairmanship of Mr. H. C. Porter, has been submitted. The recommendations of the subcommittee as approved by Committee E-8 are given later in this report.

The Advisory Committee is now functioning on a rotational basis with the terms of two members expiring each year. Messrs. F. M. Farmer and G. W. Thompson were reappointed by the Executive Committee of the Society for a three-year term, 1933 to 1936.

Of the definitions now published as tentative, the group relating to magnetic testing[1] is being recommended for adoption as standard at this annual meeting. The definitions have been completely revised by the sponsoring committee, Committee A-6 on Magnetic Properties, in order to bring them in line with the recommendations of the Sectional Committee on Definitions of Electrical Terms functioning under the procedure of the American Standards Association. These definitions cover the following terms:[1]

Units:

- Gauss
- Gilbert
- Maxwell
- Oersted

General Definitions:

- Aging, of Magnetic Materials
- Coercive Force
- Coercivity
- Core Loss Aging Coefficient
- Core Loss (Iron Loss)
- Core Loss, Standard
- Diamagnetic Material
- Eddy Current Loss
- Ferromagnetic Material
- Hysteresis Loss
- Hysteresis, Magnetic
- Intrinsic Induction in a Ferromagnetic Material
- Linkage
- Magnetic Circuit
- Magnetic Field

---

[1] The Standard Definitions, with Units and Symbols, Relating to Magnetic Testing (A 127-34) appear in the 1934 Supplement to Book of A.S.T.M. Standards, p. 69.—Ed.

Magnetic Flux
Magnetic Induction
Magnetic Potential Difference
Magnetizing Force
Magnetomotive Force
Normal Induction in a Ferromagnetic Material
Paramagnetic Material
Permeability
Permeability, Differential
Permeability, Incremental
Permeability, Initial
Permeability, Intrinsic
Permeability, Normal
Permeability, Reversible
Permeability, Space
Permeance
Reluctance
Reluctivity
Remanence
Residual Induction
Retentivity
Saturation Induction

Editorial modifications have been suggested and have met with the approval of Committee A-6.

In addition to these terms, Committee D-5 on Coal and Coke is this year recommending for adoption as standard the definition of the term coke,[1] prepared by the Subcommittee, of Committee E-8, on Coke under the chairmanship of Mr. H. C. Porter.

Glossary of Terms.—The publication of the annual glossary of terms appearing in the standards and tentative standards of the Society was omitted this year as an economy measure. This glossary, however, has been in such demand that its publication will be continued at the earliest opportunity.

Subcommittee on Definitions of the Terms Net and Gross Calorific Values (H. C. Porter, chairman).—In the 1933 report of Committee E-8 a report on behalf of this subcommittee was presented. It subsequently developed that some modification should be made in the definitions for both of these terms, as here set forth, in order to make them apply only to liquid and solid fuels and not to gaseous fuels. The present definitions as being recommended by the subcommittee and which have received the approval of Committee E-8 are as follows:

Net Calorific Value, H_l.—In the case of solid fuels and liquid fuels of low volatility, a lower value calculated from the gross calorific value as the heat produced by combustion of unit quantity, at constant atmospheric pressure, under conditions such that all water in the products remains in the form of vapor.

NOTE.—The net calorific value is calculated from the gross calorific value by making a deduction of 1020 B.t.u. per lb. (567 cal. per g.) of water derived from unit quantity of fuel, including both the water originally present as moisture and that formed by combustion. The deduction is not equal to the latent heat of vaporization of water (1050 B.t.u. per lb. at 75 F., 24 C.) because the calculation is made to reduce from gross value at constant volume to net value at constant pressure, for which the correct factor is 1020 B.t.u. per lb.

---

[1] The recommendation to adopt the definition of coke as standard was subsequently withdrawn by Committee D-5.—ED.

Gross Calorific Value, H_g.—In the case of solid fuels and liquid fuels of low volatility, the heat produced by combustion of unit quantity, at constant volume, in an oxygen bomb calorimeter under specified conditions.

NOTE.—The conditions are initial oxygen pressure of 20 to 40 atmospheres, final temperature of 68 to 95 F. (20 to 35 C.), products in form of ash, liquid water, and gaseous CO_2, SO_2 and nitrogen. This definition is not applied to gaseous or highly volatile liquid fuels.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

R. E. HESS,
Ex-Officio Secretary.

REPORT OF COMMITTEE E-9
ON
RESEARCH

In this report is presented a brief summary of some of the important research projects being carried on under the auspices of the Society. A more comprehensive review will appear later in the Society *Bulletin*.[1]

Research Committee Activities:

The Research Committee on Yield Point of Structural Steel is still having difficulty in finding means for carrying on its program of laboratory work, and the chairman has raised the question of the further continuance of that committee. The chairman and secretary of Committee E-9 have informally suggested that the Research Committee on Yield Point of Structural Steel might give consideration to a study of the *significance* of the yield point, although it should be stated that there is some difference of opinion whether such a committee should give attention to the significance of tests or whether such consideration should be left to the structural engineer. The committee will meet during this annual meeting for consideration of its future program.

The Research Committee on Fatigue of Metals[2] has continued its cooperation with *Metals and Alloys* in preparing abstracts of articles on fatigue of metals. Cooperative relations have been established between this research committee and the subcommittee of Committee E-4 on Metallography which is considering X-ray methods of metallographic study. The Committee on Fatigue of Metals has given consideration to the method of studying fatigue phenomena by the use of the "probable damage line" for metals under repeated stress,—the method devised by H. J. French,—and work on this subject by various laboratories has been planned.

The Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel is presenting two reports at this annual meeting: (1) Effect of Added Phosphorus on Low-Carbon Steel,[3] and (2) Effect of Sulfur on Forging Steel.[4] These reports complete the current work of the committee; its plans for future work on this subject, if any, will be considered at a meeting to be held during this annual meeting.

---

[1] Published as a Supplement to the *A.S.T.M. Bulletin*, October 31, 1934.—Ed.

[2] The current report of this committee appears on p. 205.—Ed.

[3] See p. 113. [4] See p. 87.

The Joint Research Committee of the A.S.M.E.—A.S.T.M. on Effect of Temperature on the Properties of Metals has been making progress in its work, which will be reported to the Society at this annual meeting.[1] In December, 1933, the committee reported to the sponsors at the meeting of the American Society of Mechanical Engineers the results of studies made at Battelle Memorial Institute on High-Temperature Creep and Fatigue Properties of Cast and Wrought High and Low-Carbon 18 per cent Chromium, 8 per cent Nickel Type Steel from Split Heats.[2] The Tentative Methods of Test for Short Time (E 21 – 33 T) and Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials (E 22 – 33 T) accepted by the Society a year ago on the recommendation of the Joint Committee, have been tried out during the year in various laboratories and certain modifications are being proposed in the light of experience thus gained.[3]

Attention is called to the appointment of a Joint Committee on Pig Iron Quality sponsored by the American Foundrymen's Association, American Institute of Mining and Metallurgical Engineers, Gray Iron Institute, Malleable Iron Research Institute and the A.S.T.M., the Society's representatives being C. D. Mathews and E. J. Edwards.

Research Projects by Standing Committees:

The usual review in the October issue of the Society *Bulletin* of the status of research projects by the standing committees had to be omitted in 1933. Committee E-9, however, through the records in the office of the Secretary, has kept currently in touch with developments in these projects, and it is expected that publication of the annual review will be resumed this year. It may be said that while the unsettled industrial and economic conditions have retarded certain projects, and especially have discouraged the initiation of new ones, very substantial progress in this field of the Society's work is being made, as perusal of the 1933 committee reports[4] and those for the present annual meeting will show.

Committee E-9 has previously called attention to the value of occasional summary by the committees of the Society of current knowledge in their particular fields. A suggestion along this line made to Committee B-7 on Light Metals and Alloys has resulted in the preparation by that committee of a comprehensive report on

---

[1] The report of the joint committee appears on p. 207.—ED.

[2] *Transactions*, Am. Soc. Mechanical Engrs., July, 1934.

[3] The methods in their revised form appear on pp. 1214 and 1223, respectively.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I (1933).

"Service Characteristics of Light Metals and Their Alloys" which is being reported to the Society this year.[1] It discusses aluminum and magnesium and their alloys under the headings: Metallurgical Characteristics, Industrial Requirements, Surface Protection, and Tabular Data. It is planned to keep this information up to date and publish revised reports periodically.

Another committee of the Society is engaged upon somewhat similar work—Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys. In 1930, this committee prepared Tables of Chemical Compositions, Physical and Mechanical Properties and Corrosion-Resistant Properties of Corrosion-Resistant and Heat-Resistant Alloys, which were published by the Society.[2] The data in these tables are being reviewed by the committee, revised in the light of recent information, and will be published in somewhat different form currently as the committee completes the various sections of the work.

Record is here made of a valuable report of a research subcommittee of Committee A-2 on Wrought Iron discussing "Quality Standards for Wrought Iron."[3] In the words of the report, it is intended "to bring about a better understanding among users of wrought iron concerning its underlying characteristics, the meaning of test results, and the various factors by which the quality may be judged." There has long been a need for just such a discussion of this subject.

Miscellaneous Administrative Matters:

The term of F. R. McMillan expired in June, 1933, and P. H. Bates was appointed to membership in his place.

The term of H. C. Mougey expires at the close of this annual meeting; the appointment of his successor will be made by the Executive Committee of the Society.

The principal of the A.S.T.M. Research Fund is $8179.35. The balance of income as of May 31, 1934, is $1419.82.

Respectively submitted on behalf of the committee,

H. F. MOORE,
Chairman.

C. L. WARWICK,
Secretary.

---

[1] See p. 277.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I (1930).

[3] See p. 129.

REPORT OF COMMITTEE E-10
ON
STANDARDS

An ever increasing number of standing committees of the Society find it convenient to refer to Committee E-10 on Standards new tentative standards and revisions of existing standards for approval for publication. The review of such standards has kept Committee E-10 quite active during the year. In addition to its regular meeting, which was held on August 16, 1933, in Philadelphia, a number of standards were handled by correspondence in instances where a very clear case had been submitted by the standing committees concerned.

What has been of equal significance, however, has been the number of proposals for new standardization projects that have come up before the committee. These are referred to elsewhere in this report. It is evident from these proposals that there is an ever increasing demand for standard specifications for materials. In this connection the committee is keeping in close touch with the activities of the National Recovery Administration and the various code authorities, since material specifications may ultimately play an important part in the national codes.

A general review of the Society's standardization activities indicated the desirability of permitting the publication as information of draft standards. On the recommendation of a special committee of the Executive Committee and Committee E-10, such publication has now been authorized by the Executive Committee provided it has the endorsement of the standing committee and of the Secretary-Treasurer. Any draft standards so published as information either in the A.S.T.M. *Bulletin* or in the trade press will be suitably designated so as to indicate that they have no official A.S.T.M. status.

As an aid to the standing committees whenever questions arise concerning the standardization procedure, the Society's regulations have been codified.

The general question of the accuracy to be expected in methods of test and the permissible variations that should be included in the Society's specifications is now being considered jointly by Committee E-10 and Committee E-1 on Methods of Testing.

The activities of Committee E-10 are set forth in this report under the following heads: Review of A.S.T.M. standardization activities, consideration of new and revised tentative standards, promotion and expansion of standardization activities, and relations with American Standards Association.

REVIEW OF A.S.T.M. STANDARDIZATION ACTIVITIES

A general summary of the new tentative standards submitted at the 1933 annual meeting, of tentative standards advanced to standard and of revisions in standards was included in the July issue of the A.S.T.M. *Bulletin*, together with a review of the standardization work of the various committees with statements concerning new standards in prospect. Much of the information, particularly in respect to standardization projects in development in committees, is furnished by the standing committees subsequent to the annual meeting and takes advantage of the fact that many committees plan their next year's work at committee meetings held during the annual meeting.

At the present writing, it is possible to make only an approximate estimate in terms of new and revised standards of the volume of standardization work accomplished during the year and reported to the Society at this meeting. The reports of standing committees to be presented at the annual meeting include recommendations to the Society substantially as follows:

New tentative standards	34
Tentative revisions of existing standards	27
Revisions of tentative standards	35
Tentative standards recommended for advancement to standard	39
Revisions of existing standards recommended for adoption as standard	13
Standards and tentative standards withdrawn	6

There are at present 466 standards and 224 tentative standards of the Society, making a total of 690, and if the above recommendations are approved this total will become 718.

CONSIDERATION OF NEW AND REVISED TENTATIVE STANDARDS

Committee E-10, on receiving recommendations from standing committees on the submission of new tentative standards or revisions of existing tentative standards or standards, reviews them principally to insure that a substantial consensus has been reached in the standing committee concerned. It requires that a complete vote be recorded analyzed according to producers, consumers, and general interests. If there are any negative votes, the names of those voting in the negative must be recorded together with the reasons for so voting. A report from the standing committee is required giving the usual information, setting forth the needs for having the standard and on what data the standard is based, that is, whether it is based on standards already in existence or on work carried out by the committee, etc.

Proposed new standards approved by Committee E-10 and published as tentative during the year are as follows:

Tentative Specifications for Steel for Bridges (A 7 – 33 T), submitted by Committee A-1 on Steel

Tentative Specifications for Steel for Buildings (A 9 – 33 T), submitted by Committee A-1 on Steel

Tentative Specifications for Mild Steel Plates (A 10 – 33 T), submitted by Committee A-1 on Steel

Tentative Specifications for Carbon-Steel Castings for Industrial, Railroad and Marine Uses (A 154 – 33 T), submitted by Committee A-1 on Steel.

Tentative Method of Determination of Phosphorus in Copper-Base Alloys in Ingot Form for Sand Castings (B 45 – 33 T), submitted by Committee B-2 on Non-Ferrous Metals and Alloys

Tentative Specifications for Aluminum Sheet and Plate (B 25 – 33 T), submitted by Committee B-7 on Light Metals and Alloys, Cast and Wrought

Tentative Specifications for Aluminum-Base Alloy Sand Castings (B 26 – 33 T), submitted by Committee B-7 on Light Metals and Alloys, Cast and Wrought

Tentative Specifications for Aluminum-Base Sand-Casting Alloys in Ingot Form (B 58 – 33 T), submitted by Committee B-7 on Light Metals and Alloys, Cast and Wrought

Tentative Specifications for Aluminum-Alloy (Duralumin) Sheet and Plate (Aluminum-Copper-Magnesium-Manganese) (B 78 – 33 T), submitted by Committee B-7 on Light Metals and Alloys, Cast and Wrought

Tentative Specifications for Aluminum-Manganese Alloy Sheet and Plate (B 79 – 33 T), submitted by Committee B-7 on Light Metals and Alloys, Cast and Wrought

Tentative Specifications for Magnesium Ingot and Stick for Remelting (B 92 – 33 T), submitted by Committee B-7 on Light Metals and Alloys, Cast and Wrought

Tentative Method of Test for Determining Gum Content of Gasoline (D 381 – 34 T), submitted by Committee D-2 on Petroleum Products and Lubricants

Tentative Methods of Testing Rubber Belting Used for Power Transmission (D 378 – 33 T), submitted by Committee D-11 on Rubber Products

Tentative Methods of Test for Rubber Hose—Braided Construction (D 379 – 33 T), submitted by Committee D-11 on Rubber Products

Tentative Methods of Test for Rubber Hose—Wrapped Construction (D 380 – 33 T), submitted by Committee D-11 on Rubber Products

Tentative Methods of Impact Testing of Metallic Materials (E 23 – 33 T), submitted by Committee E-1 on Methods of Testing

Revisions of the following existing standards and tentative standards were approved by Committee E-10:

Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 - 33 T), submitted by Committee B-2 on Non-Ferrous Metals and Alloys

Tentative Specifications for Aluminum-Alloy (Duralumin) Bars, Rods and Shapes (Aluminum-Copper-Magnesium-Manganese) (B 89 - 33 T), submitted by Committee B-7 on Light Metals and Alloys, Cast and Wrought

Tentative Specifications for Clay Sewer Pipe (C 13 - 33 T), submitted by Committee C-4 on Clay Pipe

Tentative Specifications and Tests for Load-Bearing Concrete Masonry Units (C 90 - 33 T), submitted by Committee C-10 on Hollow Masonry Building Units

Tentative Method of Sampling Coke for Analysis (D 346 - 33 T), submitted by Committee D-5 on Coal and Coke

Standard Method of Test for Size of Anthracite (D 310 - 31), submitted by Committee D-5 on Coal and Coke

Tentative Specifications for Insulated Wire and Cable: 30 per cent Hevea Rubber (D 27 - 33 T), submitted by Committee D-11 on Rubber Products

Tentative Specifications for Insulated Wire and Cable: Performance Rubber Compound (D 353 - 33 T), submitted by Committee D-11 on Rubber Products

Tentative Methods of Rockwell Hardness Testing of Metallic Materials (E 18 - 33 T), submitted by Committee E-1 on Methods of Testing

PROMOTION AND EXPANSION OF STANDARDIZATION ACTIVITIES

Consideration has been given by Committee E-10 to expansion of the Society's standardization activities in several important directions. A number of suggestions from various sources have been referred to existing committees for development, namely, testing of zeolites for water softening to Committee D-19 on Water for Industrial Uses, specifications for and methods of testing asphalt plank to Committee D-4 on Road and Paving Materials, specifications for sheet copper for roofing to Committee B-5 on Copper and Copper Alloys, Cast and Wrought, and specifications for lead-coated copper to Committee B-2 on Non-Ferrous Metals and Alloys.

The general subject of soils has been under consideration for some time and an approach is now being made to the subject through Committee D-4 on Road and Paving Materials from the aspect of soil as a subgrade and paving material. A discussion of this subject will be introduced by a paper on the program of this annual meeting.[1]

The subject of gaseous fuels has been under consideration for the past year. A conference of representatives of the various industries and national organizations interested was held in Washington, D. C., on March 7, 1934, when preliminary consideration was given to the desirability of organizing a standing committee to deal with this subject. A study committee appointed at this conference has since defined the scope of the project more definitely and a further conference will be held at this annual meeting when a decision will be reached as to whether the project of gaseous fuels should be undertaken by the Society.

---

[1] C. A. Hogentogler and E. A. Willis, "Subgrade Soil Testing Methods," *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part II, p. 693 (1934).

Other subjects still being considered by Committee E-10 are paper and allied products, heat insulation, glues and other types of adhesives, phenolic and similar resins, abrasives, and soap having particularly in mind its use as a lubricant.

The following topics have been suggested at various times as offering possibilities for development in the field of engineering materials. However, in view of the more important projects to be developed, standardization in these fields is to be deferred for the present: plating salts and anodes, porous materials, heavy chemicals, caulking compounds, starches for use in textiles, and acoustical materials.

The question of initiating work on the testing of foundry sands and developing specifications for this product was considered during the year. A conference on the subject held in Washington, D. C., on March 8, 1934, reached the conclusion that no A.S.T.M. committee on foundry sands should be organized at the present time since work on testing foundry sands was being handled quite adequately by the American Foundrymen's Association.

RELATIONS WITH AMERICAN STANDARDS ASSOCIATION

Standards Submitted Under Proprietary Sponsorship Procedure.—The proprietary sponsorship procedure for submitting standards to the American Standards Association is particularly appropriate for a large number of A.S.T.M. standards. A number of standing committees now have under consideration the submission of existing A.S.T.M. standards to the A.S.A. under this method. The following standards have been approved during the year by the A.S.A. as American Standards:

Standard Specifications for Carbon-Steel and Alloy-Steel Blooms, Billets and Slabs for Forgings (A 17 – 29) (A.S.A. No. G 9.1 – 1933)

Standard Methods of Routine Analysis of White Pigments (D 34 – 33) (A.S.A. No. K 15 – 1933)

Standard Methods of Routine Analysis of Dry Red Lead (D 49 – 33) (A.S.A. No. K 16 – 1933)

Standard Specifications for Gypsum (C 22 – 25) (A.S.A. No. A 49.1 – 1933)

Standard Specifications for Calcined Gypsum (C 23 – 30) (A.S.A. No. A 49.2 – 1933)

Standard Specifications for Gypsum Plasters (C 28 - 30) (A.S.A. No. A 49.3 - 1933)

Standard Specifications for Gypsum Molding Plaster (C 59 - 30) (A.S.A. No. A 49.4 - 1933)

Standard Specifications for Gypsum Pottery Plaster (C 60 - 30) (A.S.A. No. A 49.5 - 1933)

Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 - 33) (A.S.A. No. K 18 - 1933)

Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (E 2 - 30) (A.S.A. No. Z 30.1 - 1933)

Standards Submitted Under Sectional Committee Procedure.—Reports have been received from several of the sectional committees for which the Society is sponsor, submitting standards to the A.S.A. for approval. These reports have been transmitted to that association and the following standards have been approved during the year:

On the Recommendation of Sectional Committee B36 on Wrought-Iron and Wrought-Steel Pipe and Tubing:

Standard Specifications for Welded and Seamless Steel Pipe (A 53 - 33), American Standard (No. B 36.1 - 1934)

Standard Specifications for Welded Wrought-Iron Pipe (A 72 - 33), American Standard (No. B 36.2 - 1934)

Tentative Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 - 33 T), American Tentative Standard (No. B 36.3 - 1934)

Tentative Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 30 in. and over) (A 134 - 32 T), American Tentative Standard (No. B 36.4 - 1934)

Tentative Specifications for Electric-Resistance-Welded Steel Pipe (A 135 - 32 T), American Tentative Standard (No. B 36.5 - 1934)

Tentative Specifications for Forge-Welded Steel Pipe (A 136 - 32 T), American Tentative Standard (No. B 36.6 - 1934)

Tentative Specifications for Lock-Bar Steel Pipe (A 137 - 32 T), American Tentative Standard (No. B 36.7 - 1934)

Tentative Specifications for Riveted Steel and Wrought-Iron Pipe (A 138 - 32 T), American Tentative Standard (No. B 36.8 - 1934)

Tentative Specifications for Electric-Fusion-Welded Steel Pipe (Sizes 8 in. to but not Including 30 in.) (A 139 - 32 T), American Tentative Standard (No. B 36.9 - 1934)

On the Recommendation of Sectional Committee G8 on Zinc Coating of Iron and Steel:

Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products (A 123 - 33), American Standard (No. G 8.1 - 1933)

On the Recommendation of Sectional Committee Z11 on Petroleum Products and Lubricants:

Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (D 88 - 33), American Standard (No. Z 11.2 - 1933)

Standard Method of Test for Precipitation Number of Lubricating Oils (D 91 – 33), American Standard (No. Z 11.30 – 1933)

Standard Method of Test for Flash and Fire Points by Means of Open Cup (D 92 – 33), American Standard (No. Z 11.6 – 1933)

Standard Method of Test for Cloud and Pour Points (D 97 – 33), American Standard (No. Z 11.5 – 1933)

Standard Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil (D 129 – 33), American Standard (No. Z 11.13 – 1933)

Standard Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (D 287 – 33), American Standard (No. Z 11.31 – 1933)

Standard Method of Test for Dilution of Crankcase Oils (D 322 – 33), American Standard (Z 11.29 – 1933)

Tentative Method of Test for Penetration of Greases and Petrolatum (D 217 – 33 T), American Tentative Standard (No. Z 11.3 – 1933)

Recently, on the recommendation of Sectional Committee A2 on Fire Tests of Materials and Construction, the Standard Specifications for Fire Tests of Building Construction and Materials (C 19 – 33) have been submitted to the A.S.A. for approval as American Standard.

Sectional Committees Organized.—A Sectional Committee on Specifications and Methods of Test for Safety Glass was organized under the procedure of the American Standards Association. The Society is interested in this subject and accordingly appointed as its representative on the committee, Mr. H. C. Mougey with the Assistant Secretary as alternate.

Sectional Committee C59 on Specifications and Methods of Test for Electrical Insulating Materials, to which reference was made in the report of the committee last year,[1] was organized under the procedure of the American Standards Association with the Society as sole sponsor at a meeting held in Philadelphia on March 17, 1934. Several standing committees of the Society have already recommended to the sectional committee a number of standards under their jurisdiction for submission to the A.S.A. for approval as American Standard. It is expected that this committee will be very helpful in coordinating the work now in process in the various standing committees and in the review of standards to insure that they are entirely acceptable to industry.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

C. L. WARWICK,
Ex-Officio Secretary.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 507 (1933).

A.S.T.M.
TENTATIVE STANDARDS

ISSUED OR REVISED, 1934

The term Tentative Standard is applied to a proposed Standard which is printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action toward its adoption as standard.

Members of the Society and others are invited to direct written criticism of any of these Tentative Standards to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

TENTATIVE SPECIFICATIONS
FOR
COLD-ROLLED STRIP STEEL[1]

A.S.T.M. Designation: A 109 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1926; Revised, 1927, 1934.

The name "Cold-Rolled Strip Steel" covers a very wide range of material. After annealing the metal, any amount of cold work may be done by cold rolling, ranging from a pass between the "levelling" or "breaker rolls" which does not appreciably reduce the gage of the metal, on through various light "pincher-passes" between planishing rolls, up to regular cold rolling that may affect as much as a 50 per cent reduction in thickness. Every different amount of reduction produces a different set of physical properties. Differences in chemical composition, history of the steel itself, and its annealing, likewise cause variations in the final properties.

It is impractical to set up a multitude of specifications for cold-rolled strip steel to cover all minor gradations of "temper" that have come into use. So it is the established custom in the trade to classify this material rather roughly into five grades or tempers, ranging from No. 1, full hard, to No. 5, dead soft. Some manufacturers add a Grade No. 6 which is similar to Grade No. 5 but with special selection of chemical composition to attain the maximum of ductility. Each temper is suitable for a general type of work, as indicated in the table given in the Appendix.

The demarcation between cold-rolled sheets and cold-rolled strip is as follows:

Cold-Rolled Sheets:

(*a*) All widths 24 in. and wider.

(*b*) Over 12 in. up to 23$\frac{15}{16}$ in. in width which are not in coils and are 0.028 in. and under in thickness.

Cold-Rolled Strip:

(*a*) All widths 12 in. and narrower.

(*b*) Over 12 in. up to 23$\frac{15}{16}$ in. in width which are in coils; and both flat and coiled stock 0.029 in. and over in thickness.

The bend test is the only physical property prescribed in these specifications. A tabulation of approximate values for tensile strength, elongation, Rockwell hardness, and depth of cup corresponding to the five commercial tempers of cold-rolled strip steel is presented in the Appendix as a matter of general information.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

Scope

1. These specifications cover five grades or tempers of commercial cold-rolled, strip steel as follows:

Grade No. 1, or "Hard" temper;
Grade No. 2, or "Half-Hard" temper;
Grade No. 3, or "Quarter-Hard" temper;
Grade No. 4, or "Soft or Planished" temper;
Grade No. 5, or "Dead Soft" temper.

Selection of Temper

2. These five grades or tempers of cold-rolled strip steel cover all uses, from plain flat blanking, through easy bending, shallow drawing and stamping, up to fairly deep drawing, to drifting and very deep drawing. Each temper is capable of subdivision for obtaining products especially suited to particular uses (Note).

NOTE.—By consulting with the manufacturer, the purchaser can obtain a closely graded product for any particular job. For difficult, and indeed for most applications, this is the best procedure.

Process

3. The steel for Grades Nos. 3, 4 and 5 shall be made by either or both of the following processes: open-hearth or electric-furnace. Rimmed steel is in general use, but killed steel may be used, although it is generally a little harder than the rimmed steel.

Chemical Composition

4. The steel shall conform to the following requirements as to chemical composition:

GRADES NOS. 1 AND 2	
Carbon, per cent	0.04 to 0.12 and for some uses up to 0.25 max. will be permissible.
GRADES NOS. 3, 4 AND 5	
Carbon, per cent	0.04 to 0.12
Manganese, per cent	0.30 to 0.50
Phosphorus, max., per cent	0.04
Sulfur, max., per cent	0.055

Samples for Chemical Analysis

5. Samples for chemical analysis shall be taken by machining the entire cross-section of the strip.

Bend Tests

6. (*a*) The bend test specimens shall stand being bent cold as specified below without cracking on the outside of the bent portion:

GRADE	TEMPER	
No. 1	Hard	Not required to make bends in either direction of grain.
No. 2	Half Hard	Bend to a sharp[a] right angle across the grain.[b]
No. 3	Quarter Hard	Bend flat upon itself across the grain and to a sharp[a] right angle along the grain.[b]
No. 4	Soft or Planished	Bend flat upon itself both ways of the grain.[b]
No. 5	Dead Soft	Bend flat upon itself both ways of the grain.[b]

---

[a] Edge of forming tool shall be slightly "broken" (that is beveled) to give the equivalent of a radius = 0.010 in., which may be considered as "commercially sharp."

[b] To bend across the grain means that the crease formed by the bend shall be at right angles to the length of the cold-rolled strip. To bend along the grain means that the crease formed by the bend shall be parallel with the length of the cold-rolled strip.

(*b*) *Bend Test Specimens.*—Bend test specimens shall be $\frac{1}{2}$ in. or more in width, and of any convenient length. The edges shall be rounded with a file to remove sharp corners and burrs due to shearing.

(*c*) *Number of Bend Tests.*—Three bend tests, if concordant, shall be considered representative of each coil (or strip) selected for test.

Permissible Variations in Thickness

7. The thickness of the strip shall not vary from the thickness specified by more than the following:

Thickness, in.	Permissible Variations in Thickness, plus or minus, in.						
	Widths Up to 2 in., inclusive	Widths Over 2 to 6 in., inclusive	Widths Over 6 to 9 in., inclusive	Widths Over 9 to 12 in., inclusive	Widths Over 12 to 14 in., inclusive	Widths Over 14 to 16 in., inclusive	Widths Over 16 to $23\frac{15}{16}$ in., inclusive
0.080 and over	0.002	0.003	0.004	0.004	0.004	0.004	0.005
Under 0.080 to 0.035, incl	0.0015	0.002	0.003	0.003	0.003	0.003	0.004
Under 0.035 to 0.030, incl	0.0015	0.0015	0.002	0.002	0.002	0.002	0.003
Under 0.030 to 0.025, incl	0.001	0.0015	0.002	0.002	0.002	0.002	......
Under 0.025 to 0.020, incl	0.001	0.0015	0.002	0.002	0.002	......	......
Under 0.020 to 0.015, incl	0.001	0.001	0.0015	0.0015	......	......	......
Under 0.015 to 0.010, incl	0.001	0.001	......	......	......	......	......
Under 0.010 to 0.006, incl	0.00075	0.00075	......	......	......	......	......
Under 0.006	0.0005	0.0005	......	......	......	......	......

NOTE.—The above table applies to the product of narrow cold-rolled strip mills. The new type wide strip mills yield a product that has the same tolerances for all widths (as the narrower widths are made by slitting wide metal). These tolerances are appreciably greater for strip under 6 in. in width; are about the same for widths from 6 to 16 in.; and are somewhat less for strip over 16 in. in width. Proposed thickness tolerances not as yet accepted by all wide strip mills, are as follows:

THICKNESS, IN.	PERMISSIBLE VARIATIONS IN THICKNESS (ALL WIDTHS UP TO $23\frac{15}{16}$ IN.)
0.126 to 0.249	±0.005 in.
0.066 to 0.125	±0.004 in.
0.031 to 0.065	±0.003 in.
0.021 to 0.030	±0.002 in.
0.011 to 0.020	±0.0015 in.

Permissible Variations in Width

8. The width of the strip shall not vary from that specified by more than the following:

	Width Tolerances, in.		
	Widths Up to $5\frac{1}{2}$ in.	Widths $5\frac{1}{2}$ to 12 in., incl.	Widths Over 12 in.
All Thicknesses, Mill Edge	$\pm\frac{3}{64}$	$\pm\frac{5}{64}$	$\pm\frac{3}{32}$
All Thicknesses and Widths, Sheared Edge	±0.008 in. unless rolled afterwards when the tolerances shall be −0.008 in. and $+\frac{1}{64}$ in.		

Length

9. (*a*) Cold-rolled strip is usually furnished in coils, but may be furnished in cut lengths when ordered. Unless otherwise specified, the cut lengths shall be 8 ft. and ends. When so furnished the permissible variation in length shall be +3 in. with no minus tolerance.

(*b*) When a definite length in inches is specified, the permissible variation shall be +1 in. with no minus allowance. Cutting to definite lengths of 36 in. or over does not relieve the purchaser from scrap loss and short lengths will be included, cut to multiples, if so desired.

Straightness

10. The standard for straightness shall be ½ in. bow in 8 ft.

Flatness

11. When flatness of strip steel is essential, it shall be so specified by the purchaser. Flatness shall be determined by placing the strips in 8-ft. lengths on a flat surface. No part of the strip shall rise more than ¼ in. from the surface. It shall lie flat of its own weight, with no spring up from the flat surface.

Finish

12. Cold-rolled strip steel shall have a bright, smooth surface and shall be free from injurious defects.

Inspection

13. (*a*) The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture may be made prior to shipment, and such inspection shall be final. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) In case material is not inspected at the place of manufacture, the purchaser may make the tests to govern the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection

14. (*a*) Unless otherwise specified, any rejections based on tests made in accordance with Section 13 (*b*) shall be reported within ten working days from the receipt of samples.

(*b*) Material which shows injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified within 90 days from the date of the receipt of the material by the purchaser.

(*c*) Samples tested in accordance with Section 13 (*b*) which represent rejected material, shall be preserved for one month from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

APPENDIX

To specify chemical composition and tensile strength, together with the percentage elongation in 2 in. does not sufficiently define the properties of cold-rolled strip steel to insure satisfactory material for use in many applications. Freedom from "stretcher strains" during forming, or perhaps equiaxed grains, may be vital, whereas, the tensile strength may be of only minor importance.

TABLE AI.—APPROXIMATE PHYSICAL PROPERTIES FOR VARIOUS TEMPERS OF COLD-ROLLED STRIP STEEL.

(These values are given as information only and are not intended as criteria for acceptance or rejection.)

Grade or Temper	Hardness (Rockwell "B" Scale), ($\frac{1}{16}$-in. Ball 100-kg. Load)	Depth of Cup for 0.050-in. Thickness of Strip, mm.[a]	Tensile Strength, lb. per sq. in.[b]	Elongation in 2 in. for 0.050-in. Thickness of Strip, per cent[c]	Remarks
No. 1 Hard	88 ± 5[d]	6 to 7	80 000 ± 12 000	3 ± 2	Intended for flat blanking only.
No. 2 Half-Hard	80 ± 5	7 to 8	64 000 ± 8 000	9 ± 5	Intended for easy bending up to 90 deg. across the grain.[e] (No bending along the grain).
No. 3 Quarter-Hard	69 ± 5	8 to 9	54 000 ± 6 000	20 ± 7	For shallow drawing and stamping, where a very smooth surface is required. Bends 180 deg. across the grain. Bends up to 90 deg. along the grain.[e]
No. 4 Soft or Planished	58 ± 6	9 to 10½	48 000 ± 5 000	30 ± 6	For fairly deep drawing where no sign of surface strain[f] is permissible. Bends 180 deg. both ways of the grain.
No. 5 Dead Soft	45 ± 7	10 to 11½	44 000 ± 4 000	39 ± 6	For deep drawing where slight stretcher strains[f] are permissible. Also for drifting. (Erroneously called "extrusion.") Bends 180 deg. both ways of the grain.

[a] Cup depth varies with thickness of strip. For Grade No. 5, dead soft temper, the depth is given approximately by the formula, $D = 10.5 \text{ mm.} + 6.4 \log \text{"t"}$ (t = thickness in mm.). Other tempers vary in a similar way.

[b] Tensile properties are based on the standard tension test specimen for sheet metals, see Fig. 7 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials, see 1933 Book of A.S.T.M. Standards, Part I, p. 949.

[c] Elongation in 2 in. varies with thickness of strip. For Grade No. 5, dead soft temper, the percentage elongation $= 41 + 10 \log \text{"t"}$ (t = thickness in mm.). Other tempers vary in a similar way.

[d] Grade No. 1, hard temper, may run harder than the maximum hardness limits given, in some cases reaching a range of 100±5 Rockwell B with corresponding values for tensile strength and depth of cup.

[e] To bend across the grain means that the crease formed by the bend shall be at right angles to the length of the cold-rolled strip. To bend along the grain means that the crease formed by the bend shall be parallel with the length of the cold-rolled strip.

[f] See third paragraph of the Appendix as to "age hardening" and the necessity for using steel promptly after rolling where stretcher strains are to be entirely absent.

Experienced purchasers have found that, for all difficult jobs, the safest specification is that the steel shall be suitable for a given use (that is, suitable for making some specific part or article, as shown by a sample or by a blueprint showing method of manufacture). By specifying certain physical properties the purchaser assumes the responsibility of steel furnished to those specifications as being satisfactory, whereas, by ordering steel to be suitable for a specific job he places the responsibility upon the manufacturer.

While strip steel in the "dead soft" or annealed condition has the maximum ductility, it is unsuited to many forming operations due to its tendency to "stretcher strain." A small amount of cold rolling will prevent this, but the effect is only temporary, due to the phenomenon called "aging." In general, the higher the storage temperature, and the less the amount of skin-rolling, or temper-rolling, after final annealing, the shorter the elapsed time necessary for stretcher straining to recur. This is accompanied by an increase in hardness, yield point, and tensile strength and a decrease in ductility. For those jobs on which stretcher straining or breakage is likely to occur, the material should be fabricated as promptly as possible after temper cold rolling.

The following table of approximate physical properties corresponding to the five commercial tempers of cold-rolled strip steel, is presented as a matter of general information, to give a general view of the field covered. The limits of hardness, tensile strength, etc., in the table are not intended as criteria for acceptance or rejection unless specifically agreed to by the manufacturer when accepting the order. The exact processing by different manufacturers will naturally vary slightly, so that absolute identity cannot be expected in their commercial tempers of cold-rolled strip steel.

TENTATIVE SPECIFICATIONS
FOR
ELECTRIC-FUSION-WELDED STEEL PIPE[1]
(SIZES 8 IN. TO BUT NOT INCLUDING 30 IN.)

A.S.T.M. Designation: A 139 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1932; REVISED, 1934.

Scope. 1. These specifications cover two grades of electric-fusion-welded steel pipe in sizes 8 in. to but not including 30 in. in diameter, and wall thicknesses up to $\frac{5}{8}$ in., inclusive, which is intended for conveying liquid, gas or vapor at temperatures below 450° F. and is adapted for flanging and bending. The suitability of pipe for various purposes is somewhat dependent upon its dimensions and properties and conditions of service, so that the purpose for which the pipe is intended should be stated in the order.[2]

MANUFACTURE

Process. 2. Unless otherwise specified, the steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. The steel shall conform to the following requirements as to chemical composition:

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

[2] It is the opinion of Committee A-1 on Steel that steel made in accordance with the following specifications of the American Society for Testing Materials can be welded satisfactorily by the usual fusion-welding processes now in general use. Therefore, if desired by purchaser, material ordered under any of the following specifications may be substituted for that specified in Sections 3 and 6:

Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A 78), Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89), Steel for Bridges (A 7), Steel for Buildings (A 9), Mild Steel Plates (A 10), Structural Steel for Locomotives and Cars (A 113), Boiler and Firebox Steel for Locomotives (A 30), Boiler and Firebox Steel for Stationary Service (A 70), Marine Boiler Steel Plates (A 114), Open-Hearth Iron Plates of Flange Quality (A 129), Structural Steel for Ships (A 131).

In connection with carbon limitations in the above specifications, the committee was of the opinion that, while higher carbon steels are successfully welded, commercial practice at present often limits the carbon (by check analysis) to 0.35 per cent in open-hearth steel.

Phosphorus, maximum, per cent	0.045
Sulfur, maximum, per cent	0.060

Ladle Analyses. 4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. When requested by the purchaser, the chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 3.

Check Analyses. 5. (*a*) Analyses of two pipe from each lot of 200 lengths or fraction thereof of each size 8 in. to 20 in., and from each lot of 100 lengths or fraction thereof of each size over 20 in. up to 30 in., may be made by the purchaser from the finished pipe. By agreement between the manufacturer and the purchaser, the analysis may be made on the skelp and the number shall be determined in the same manner as when taken from the finished pipe. The chemical composition thus determined shall conform to the requirements specified in Section 3. Drillings for analysis shall be taken from several points around each pipe, or across each piece of skelp, selected for analysis.

(*b*) *Retests.*—If the analysis of either length of pipe or length of skelp does not conform to the requirements specified in Section 3, analyses of two additional lengths from the same lot shall be made, each of which shall conform to the requirements specified.

PHYSICAL PROPERTIES AND TESTS

Tension Tests. 6. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

	GRADE A	GRADE B
Tensile strength, lb. per sq. in	48 000	60 000
Yield point, lb. per sq. in	30 000	35 000
Elongation in 2 in., per cent	30	25

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine or other approved method.

(*c*) The tensile strength across the weld shall be not less than the minimum tensile strength of the grade of steel ordered.

Bend Tests. 7. If required by the purchaser, the test specimen taken across the weld shall stand being bent cold through 180 deg. around a pin the diameter of which is equal to 4½ times the thickness of the plate, without developing cracks. In making the bend test, the side of the specimen representing the inside of the pipe shall be placed next the pin.

Hydrostatic Tests. 8. (*a*) Pipe shall be tested at the mill to a hydrostatic pressure calculated from the following formula:

$$P = \frac{2\,St}{D}$$

where P = the minimum hydrostatic test pressure in pounds per square inch;

S = the allowable fiber stress: 16,000 to 18,000 lb. per sq. in. for Grade A; 20,000 to 22,000 lb. per sq. in. for Grade B, but in no case shall the hydrostatic pressure exceed 2500 lb. per sq. in. The stress produced shall not be more than 80 per cent of the specified yield point.

t = the wall thickness in inches; and

D = the outside diameter in inches.

(*b*) The hydrostatic pressure shall be maintained for not less than 5 seconds and, while under test pressure, the pipe shall be jarred near both ends with a 2-lb. hammer or its equivalent.

Test Specimens. 9. (*a*) Longitudinal tension test specimens shall be taken from the end of the pipe at a point approximately 90 deg. from the weld, and shall not be flattened between gage marks. Transverse tension test specimens shall be taken across the weld and from the same end of the pipe as the longitudinal test specimen. The sides of each specimen shall be parallel between gage marks. When impracticable to pull a test specimen in full thickness the A.S.T.M. standard 2-in. gage length test specimen may be used. By agreement between the manufacturer and the purchaser, the longitudinal tension test specimen may be taken from the skelp.

(*b*) The bend test specimen shall have the protruding portions of the weld, from both inside and outside of the pipe, removed by machining or grinding.

(*c*) All specimens shall be tested at room temperature.

(*d*) Where specimens are taken from points other than the ends of pipe, the openings resulting from the removal of test specimens shall be patched in a manner approved by the purchaser.

Number of Tests. 10. (*a*) One longitudinal and one transverse tension test and one bend test shall be made on one length from each lot of 200 lengths or fraction thereof of each size 8 in. up to 20 in., and on one length from each lot of 100 lengths or fraction thereof of each size 20 in. up to 30 in. When taken from the skelp, the number of tests shall be determined in the same manner as when taken from the finished pipe

(*b*) Each length of pipe shall be subjected to the hydrostatic test specified in Section 8.

Retests. 11. (*a*) If the results of the tension or bend tests of any lot do not conform to the requirements specified in Sections 6 and 7, two retests for each failure shall be made from separate lengths of the same lot, each of which shall conform to the requirements specified.

(*b*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen, as indicated by scribe scratches marked on the specimen before testing, the specimen may be discarded and another substituted.

(*c*) If any specimen shows defective machining or develops flaws not associated with the welding it may be discarded and another specimen substituted.

WEIGHTS, DIMENSIONS, AND PERMISSIBLE VARIATIONS

Permissible Variations.

12. (*a*) *Weight.*—The weight of any length of pipe shall not vary more than 3.5 per cent under or 10 per cent over that specified, but the carload weight shall be not more than 1.75 per cent under the nominal weight.

(*b*) *Diameter.*—The outside diameter shall not vary more than 1 per cent over or under the nominal size specified.

(*c*) *Ends, Plain End Pipe.*—Unless otherwise specified, plain end pipe for use with the Dresser or Dayton type coupling shall be reamed both outside and inside sufficiently to remove all burrs. Plain end pipe for welding shall be beveled on the outside to an angle of 45 deg. with a width of flat at the end of the pipe of $\frac{1}{16}$ in. ± $\frac{1}{32}$ in. Where material is ordered beveled to any other than a 45-deg. angle it should be understood that the angle is to be measured from a line drawn perpendicular to the axis of the pipe. This means that a greater amount of material is removed with a 60-deg. angle than with a 45-deg. angle.

Pipe shall be suffiicently free from indentations, projections, or roll marks for a distance of 8 in. from the end of the pipe to make a tight joint with the rubber gasket type of coupling.

All plain end pipe intended for Dresser or Dayton type joints or for welding sizes $10\frac{3}{4}$ in. in outside diameter and smaller, shall be not more than $\frac{1}{32}$ in. smaller than the nominal outside diameter for a distance of 8 in. from the end of the pipe and shall permit the passing for a distance of 8 in. of a ring gage which has a bore $\frac{1}{16}$ in. larger than the nominal outside diameter of the pipe. Sizes larger than $10\frac{3}{4}$ in. in outside diameter shall be not more than $\frac{1}{32}$ in. smaller than the nominal outside diameter for a distance of 8 in. from the end of the pipe and shall permit the passing for a distance of 8 in. of a ring gage which has a bore $\frac{3}{32}$ in. larger than the nominal outside diameter of the pipe.

(*d*) *Ends, Threaded Pipe.*—Each end of threaded pipe shall be reamed to remove all burrs. All threads shall be in accordance with the American Standard Pipe Threads[1] and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. The variation from the standard when tested with the standard working gage shall not exceed one and one-half turns either way. Pipe shall not be rounded-out by hammering in order to get a full thread. There shall be not more than two black threads for $\frac{3}{4}$-in. taper among the perfect threads. Black threads should not be confused with imperfect threads, such as torn, shaven, or broken.

(*e*) Each length of threaded pipe shall be provided with one coupling, having clean-cut threads of such a pitch diameter as to make a tight joint.

(*f*) *Thickness.*—Minimum wall thickness at any point shall be not more than 12.5 per cent under the nominal wall thickness specified.

Lengths.

13. Unless otherwise specified, pipe shall be furnished in lengths averaging 38 ft. or over, with a minimum length of 20 ft., but not more than 5 per cent may be under 32 ft. Jointers made by welding are permissible. Where threaded pipe is ordered, jointers shall be made by threading and shall not exceed 5 per cent of the order.

WORKMANSHIP AND FINISH

Workmanship and Finish.

14. The finished pipe shall be reasonably straight and free from injurious defects (Note). Defects in excess of 12.5 per cent of the nominal wall thickness shall be considered injurious.

NOTE.—The weld shall show thorough penetration and good fusion with no appreciable under-cutting and shall be at least flush with the surface of the pipe. The weld metal shall not project more than 50 per cent of the wall thickness for pipe $\frac{3}{16}$ in. or less in thickness; not over 30 per cent for pipe over $\frac{3}{16}$ in. up to and including $\frac{3}{8}$ in. in thickness; and not over 25 per cent for pipe over $\frac{3}{8}$ in. in thickness.

Repairing Defects.

15. (*a*) Welding by electric fusion of injurious defects in the pipe wall will be permitted, provided their depth does not exceed one-third the specified wall thickness.

(*b*) Minor defects in the welds, such as sweats or leaks, shall be repaired at the discretion of the manufacturer. Repairs of this nature shall be made by completely removing the defect, cleaning the cavity and then fusion welding.

(*c*) All repaired pipe shall be retested hydrostatically.

MARKING

Marking.

16. Each length of pipe shall be legibly marked with appropriate symbols by stenciling, stamping, or rolling to show by whom manufactured, the grade of pipe, and that it conforms to these specifications.

---

[1] A complete description of American Standard Pipe Threads applicable to pipe, valves and fittings is contained in the Pipe Thread Bulletin published by the American Standards Association, A.S.A. Standard No. B 2–1919.

PROTECTIVE COATING

Protective Coating.

17. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall then be given a protective coating as specified.

INSPECTION AND REJECTION

Inspection.

18. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the inspection of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

19. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
BLACK AND HOT-DIPPED ZINC-COATED (GALVANIZED) WELDED AND SEAMLESS STEEL PIPE FOR ORDINARY USES[1]

A.S.T.M. Designation: A 120 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1928; REVISED, 1932, 1934.

Scope

1. These specifications cover black and hot-dipped galvanized "standard weight," "extra strong," and "double extra strong" welded and seamless steel pipe. Pipe ordered under these specifications is intended for ordinary uses such as low-pressure service in steam, water and gas lines, and is not intended for close bending or coiling, or high-temperature service. No physical tests are specified on pipe made to these specifications, except hydrostatic tests which shall be made at the mills, as these specifications are intended to cover pipe purchased mainly from jobber's stocks. When tension and other tests are required, pipe may be purchased in accordance with the Standard Specifications for Welded and Seamless Steel Pipe (A.S.T.M. Designation: A 53) of the American Society for Testing Materials.[2]

MANUFACTURE

Process

2. (*a*) The steel for welded pipe shall be of soft weldable quality made by one or more of the following processes: open-hearth, electric-furnace or acid-bessemer. The steel for seamless pipe shall be made by either or both of the following processes: open-hearth or electric-furnace.

(*b*) Welded pipe 3 in. or under in nominal diameter may be butt-welded, unless otherwise specified. Welded pipe over 3 in. in nominal diameter shall be lap-welded or electric-welded.

Galvanized Pipe

3. (*a*) Galvanized pipe shall be coated with zinc inside and outside by the hot-dip process.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

[2] 1933 Book of A.S.T.M. Standards, Part I, p. 247.

(*b*) The zinc used for the coating shall be any grade of zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6) of the American Society for Testing Materials.[1]

HYDROSTATIC TESTS

Hydrostatic Tests

4. Each length of pipe shall be tested at the mill to the hydrostatic pressures specified in Table I. Welded pipe 2 in. and larger shall be jarred near one end while under test pressure.

TABLE I.—HYDROSTATIC PRESSURES FOR WELDED AND SEAMLESS STEEL PIPE.[a]
(Pressures Expressed in Pounds per Square Inch)

Size (Nominal Inside Diameter), in.	"Standard Weight" Pipe			"Extra Strong" Pipe			"Double Extra Strong" Pipe	
	Weight of Pipe per Linear Foot, Threaded and with Couplings	Butt-weld	Lap-weld, Electric-weld and Seamless	Weight of Pipe per Linear Foot, Plain Ends, lb.	Butt-weld	Lap-weld, Electric-weld and Seamless	Butt-weld	Lap-weld, Electric-weld and Seamless
⅛........	.....	700	....	.....	700	....	....	....
¼........	.....	700	....	.....	700	....	....	....
⅜........	.....	700	....	.....	700	....	....	....
½........	.....	700	....	.....	700	....	700	....
¾........	.....	700	....	.....	700	....	700	....
1.........	.....	700	....	.....	700	....	700	....
1¼........	.....	700	1000	.....	1500	2500	2200	....
1½........	.....	700	1000	.....	1500	2500	2200	3000
2.........	.....	700	1000	.....	1500	2500	2200	3000
2½........	.....	800	1000	.....	1500	2000	2200	3000
3.........	.....	800	1000	.....	1500	2000	2200	3000
3½........	.....	...	1000	.....	....	2000	....	2500
4.........	.....	...	1000	.....	....	2000	....	2500
5.........	.....	...	1000	.....	....	1800	....	2000
6.........	.....	...	1000	.....	....	1800	....	2000
8.........	25.00	...	800	.....	....	....	....	2000
8.........	28.81	...	1000	43.39	....	1500	....	....
10.........	32.00	...	600	.....	....	....	....	....
10.........	35.00	...	700	.....	....	....	....	....
10.........	41.13	...	900	54.74	....	1000	....	....
12.........	45.00	...	600	.....	....	....	....	....
12.........	50.71	...	800	65.42	....	1000	....	....

[a] For pipes over 12 in. in inside diameter, the test pressures should be calculated by the formula $P = \frac{2St}{D}$ in which P = pressure in pounds per square inch; S = fiber stress, 12,000 lb. per sq. in.; t = thickness of wall in inches; D = outside diameter in inches.

WEIGHT OF COATING

Weight of Coating

5. The weight of the zinc coating shall be not less than 2.0 oz. per sq. ft. of total coated surface. The weight of coating expressed in ounces per square foot shall be calculated by dividing the total weight

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 858.

of zinc, inside plus outside, by the total area, inside plus outside, of the surface coated.

Weight of Coating Test

6. The weight of zinc coating shall be determined by stripping specimens in accordance with the Standard Methods of Determining Weight and Uniformity of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles (A.S.T.M. Designation: A 90) of the American Society for Testing Materials.[1] The total zinc on each specimen shall be determined in a single stripping operation and the average of the results from the two specimens from each pipe shall be the weight of zinc coating.

Test Specimens

7. Test specimens for determination of weight of coating shall be cut approximately 4 in. in length from opposite ends of the length or lengths of pipe selected for testing.

Number of Tests

8. (*a*) Two test specimens for the determination of weight of coating shall be taken, one from each end of one length of galvanized pipe, selected at random in each lot of 500 lengths or fraction thereof, of each size.

(*b*) Each length of pipe shall be subjected to the hydrostatic test specified in Section 4.

Retests

9. If the weight of coating of any lot does not conform to the requirements specified in Section 5, retests of two additional pipes from the same lot shall be made, each of which shall conform to the requirements specified.

WEIGHTS, DIMENSIONS AND PERMISSIBLE VARIATIONS

Standard Weights

10. (*a*) The standard weights for pipe of various inside diameters are given in Table II.

(*b*) Nipples shall be cut from pipe of the same weight and quality described in these specifications.

Permissible Variations

11. (*a*) *Weights.*—The weight of the pipe shall not vary more than 5 per cent for standard weight and extra strong pipe nor more than 10 per cent for double extra strong pipe from that specified in Table II.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 317.

(*b*) *Diameter.*—For pipe $1\frac{1}{2}$ in. or under in nominal diameter, the outside diameter at any point shall not vary more than $\frac{1}{64}$ in. over nor more than $\frac{1}{32}$ in. under the standard specified. For pipe 2 in. or over in nominal diameter, the outside diameter shall not vary more than 1 per cent over or under the standard specified.

(*c*) *Thickness.*—The minimum wall thickness at any point shall not be more than 12.5 per cent under the nominal wall thickness.

TABLE II.—STANDARD WEIGHTS AND DIMENSIONS OF WELDED AND SEAMLESS STEEL PIPE.

Size (Nominal Inside Diameter), in.	Outside Diameter, in.	"Standard Weight" Pipe			"Extra Strong" Pipe		"Double Extra Strong" Pipe	
		Number of Threads per Inch	Thickness, in.	Weight of Pipe per Linear Foot, Threaded and with Couplings, lb.	Thickness, in.	Weight of Pipe per Linear Foot, Plain Ends, lb.	Thickness, in.	Weight of Pipe per Linear Foot, Plain Ends, lb.
$\frac{1}{8}$	0.405	27	0.068	0.25	0.095	0.31	.....	.....
$\frac{1}{4}$	0.540	18	0.088	0.43	0.119	0.54	.....	.....
$\frac{3}{8}$	0.675	18	0.091	0.57	0.126	0.74	.....	.....
$\frac{1}{2}$	0.840	14	0.109	0.85	0.147	1.09	0.294	1.71
$\frac{3}{4}$	1.050	14	0.113	1.13	0.154	1.47	0.308	2.44
1	1.315	$11\frac{1}{2}$	0.133	1.68	0.179	2.17	0.358	3.66
$1\frac{1}{4}$	1.660	$11\frac{1}{2}$	0.140	2.28	0.191	3.00	0.382	5.21
$1\frac{1}{2}$	1.900	$11\frac{1}{2}$	0.145	2.73	0.200	3.63	0.400	6.41
2	2.375	$11\frac{1}{2}$	0.154	3.68	0.218	5.02	0.436	9.03
$2\frac{1}{2}$	2.875	8	0.203	5.82	0.276	7.66	0.552	13.70
3	3.500	8	0.216	7.62	0.300	10.25	0.600	18.58
$3\frac{1}{2}$	4.000	8	0.226	9.20	0.318	12.51	0.636	22.85
4	4.500	8	0.237	10.89	0.337	14.98	0.674	27.54
5	5.563	8	0.258	14.81	0.375	20.78	0.750	38.55
6	6.625	8	0.280	19.19	0.432	28.57	0.864	53.16
[a]8	8.625	8	0.277	25.00	.....	.....	0.875	72.42
8	8.625	8	0.322	28.81	0.500	43.39	.....	.....
[a]10	10.750	8	0.279	32.00	.....	.....	.....	.....
[a]10	10.750	8	0.307	35.00	.....	.....	.....	.....
10	10.750	8	0.365	41.13	0.500	54.74	.....	.....
[a]12	12.750	8	0.330	45.00	.....	.....	.....	.....
12	12.750	8	0.375	50.71	0.500	65.42	.....	.....

[a] Unless specifically stated on the order the lighter weights will not be furnished. Weights given in the table are for pipes up to and including 12 in. in nominal inside diameter, with threaded ends and couplings; sizes larger than those shown in the table are measured by the outside diameter and will be furnished with plain ends unless otherwise specified; for such sizes it will be necessary to accept Manufacturers' weights or calculate the weights on the basis of one cubic inch of steel weighing 0.2833 lb.

Lengths

12. Unless otherwise specified, pipe lengths shall be in accordance with the following regular practice:

(*a*) Standard weight pipe shall be in random lengths of 16 to 22 ft., but not more than 5 per cent of the total number of lengths may be "jointers," which are two pieces coupled together. When ordered with plain ends, 5 per cent may be in lengths of 12 to 16 ft.

(*b*) Extra strong and double extra strong pipe shall be in random lengths of 12 to 22 ft. Five per cent may be in lengths of 6 to 12 ft.

WORKMANSHIP AND FINISH

Ends

13. Unless otherwise specified, pipe shall conform to the following regular practice:

(*a*) Each end of standard weight welded pipe shall be threaded. Extra strong welded pipe and standard weight and extra strong seamless pipe and all double extra strong pipe shall be furnished with plain ends.

Threads

(*b*) All threads shall be in accordance with the American Standard Pipe Thread[1] and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure.

Couplings

(*c*) Each length of threaded pipe shall be provided with one coupling, having clean-cut threads of such a pitch diameter as to make a tight joint. Couplings may be of wrought iron or steel.

Finish

14. (*a*) The finished pipe shall be reasonably straight and free from injurious defects. All burrs at the ends of the pipe shall be removed.

(*b*) The zinc coating on galvanized pipe shall be free from injurious defects or excessive roughness.

INSPECTION AND REJECTION

Inspection

15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

16. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

---

[1] A complete description of the American Standard Pipe Threads applicable to pipe valves and fittings is contained in the Pipe Thread Bulletin published by the American Standards Association, **A.S.A. No. B2-1919.**

TENTATIVE SPECIFICATIONS
FOR
ALLOY-STEEL CASTINGS FOR VALVES, FLANGES AND FITTINGS FOR SERVICE AT TEMPERATURES FROM 750 TO 1100 F.[1]

A.S.T.M. Designation: A 157 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1934.[2]

Scope

1. (*a*) These specifications cover alloy-steel castings for valves, pipe flanges and pipe fittings, intended for service at metal temperatures from 750 to 1100 F. (Note 1).

(*b*) Eight grades of material are included, six ferritic steels designated as F_1, F_2, F_3, F_4, F_5 and F_6, and two austenitic steels designated as A_1 and A_2, which are classified in accordance with their chemical and physical properties as specified in Sections 5 and 8. Selection will depend upon design and service conditions, physical properties, and the high-temperature characteristics (Note 2).

MANUFACTURE

Process

2. Steels F_1, F_2, F_3, F_4 and F_5 shall be made by the open-hearth, crucible or electric-furnace process. Steels F_6, A_1 and A_2 shall be made by the electric-furnace or crucible process.

Heat Treatment Required

3. (*a*) All castings shall receive, between the casting and machining operations, a heat treatment suitable to their design and chemical composition. Unless the method of heat treatment is specified by the purchaser, thus becoming a matter of agreement with

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

the manufacturer, the type of heat treatment used shall be at the option of the manufacturer. This latter condition must necessarily apply to castings for stock purposes.

(*b*) The ferritic steels F_1, F_2, F_3, F_4, F_5 and F_6 may be fully annealed, or fully annealed and drawn, or normalized and drawn, or annealed and normalized and drawn, or normalized and annealed.

(*c*) The austenitic steels A_1 and A_2 shall receive a stabilizing treatment as described in Section 4 (*d*).

Heat Treatment

4. (*a*) *Full Annealing.*—The procedure for full annealing shall consist in allowing the castings to cool after pouring, to a temperature below the critical range, reheating to the proper temperature and for the required time to refine the grain, and cooling thereafter slowly in the furnace. The castings shall not be removed from the furnace until the pyrometer shows that the furnace has fallen to a temperature below 500 F. (260 C.).

(*b*) *Normalizing.*—The procedure for normalizing shall consist in allowing the castings to cool after pouring, to a temperature below the critical range, reheating to the proper temperature and for the required time to refine the grain, and cooling in still air at room temperature.

(*c*) *Drawing or Tempering.*—The procedure for drawing, or tempering, shall consist in reheating the castings to a temperature at least 150 F. (85 C.) above the temperature to be encountered in service, and holding at that temperature not less than one and one-half hours per inch or less of wall thickness, followed by cooling in the furnace or in still air. Under no circumstances shall a drawing temperature of less than 800 F. (425 C.) be employed.

(*d*) *Stabilizing Treatment.*—The procedure for stabilizing austenitic steels shall consist in allowing the castings to cool after pouring, reheating to the proper stabilizing temperature and holding at that temperature for sufficient time, followed by rapid air cooling or by quenching in a liquid medium.

(*e*) *Temperature Regulation.*—Furnace temperatures shall be effectively regulated by means of pyrometers.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

5. (*a*) Unless otherwise mutually agreed upon between the manufacturer and purchaser, the steel shall conform to the following requirements as to chemical composition:

Class	Ferritic Steels						Austenitic Steels	
	F_1	F_2	F_3	F_4	F_5	F_6	A_1	A_2
Grade	Carbon-Molybdenum	Manganese-Molybdenum	Nickel-Chromium	Nickel-Chromium-Molybdenum	4 to 6 per cent Chromium	13 per cent Chromium	18 per cent Chromium, 8 per cent Nickel	20 per cent Nickel, 8 per cent Chromium
Carbon, per cent	0.45 max.	0.35 max.	0.45 max.	0.45 max.	0.15 to 0.35	0.15 max.	0.15 max.	0.35 max.
Manganese, per cent	1.00 max.	1.00 to 1.60	1.00 max.	1.00 max.	1.00 max.	1.00 max.	1.00 max.	1.50 max.
Phosphorus, per cent	0.05 max.	0.05 max.	0.05 max.	0.05 max.	0.05 max.	0.05 max.	0.05 max.	0.05 max.
Sulfur, per cent	0.06 max.	0.06 max.	0.06 max.	0.06 max.	0.06 max.	0.05 max.	0.05 max.	0.05 max.
Silicon, per cent	0.20 min.	0.20 min.	0.20 min.	0.20 min.	0.20 min.	1.00 max.	2.00 max.	2.00 max.
Nickel, per cent	......	....	1.00 to 2.25	0.75 to 1.50	....	0.80 max.	8.00 to 10.30	19.0 to 22.0
Chromium, per cent	......	....	0.50 to 1.00	0.50 to 1.00	4.00 to 6.50	11.5 to 13.5	17.5 to 20.0	7.00 to 9.00
Molybdenum, per cent	0.40 min.	0.20 min.	......	0.30 to 0.60	0.40 to 0.65[a]	0.50 max.	As agreed upon	......
Tungsten, per cent	......	....	......	......	0.80 to 1.25[a]	......	....	......

[a] Either molybdenum or tungsten shall be used.

Ladle Analysis

6. An analysis of each melt of steel shall be made by the manufacturer to determine the percentage of the elements specified in Section 5. This analysis shall be made from drillings taken at least ¼ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 5.

Check Analysis

7. Analysis may be made by the purchaser from castings or from broken test specimens, representing each melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 5.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

8. (*a*) The castings shall conform to the following minimum requirements as to tensile properties at room temperature:

	TENSILE STRENGTH, LB. PER SQ. IN.	YIELD POINT, LB. PER SQ. IN.	ELONGATION IN 2 IN., PER CENT	REDUCTION OF AREA, PER CENT
Grade F_1	85 000	55 000	18.0	30.0
Grade F_2	90 000	60 000	22.0	45.0
Grade F_3	100 000	65 000	18.0	30.0
Grade F_4	100 000	65 000	18.0	30.0
Grade F_5	100 000	65 000	18.0	30.0
Grade F_6	85 000	55 000	20.0	40.0
Grade A_1	70 000	30 000	35.0	40.0
Grade A_2	65 000	30 000	30.0	35.0

(*b*) Tension tests at room temperature shall be made by the manufacturer from each melt in each heat-treatment charge. Such tests may be witnessed by the purchaser or his representative, or reported to him, as may be specified in the order. The results of these tests shall conform to the minimum tensile properties specified in Paragraph (*a*). Authentic test records of tests made during manufacture of stock valves shall be accepted in lieu of witness tests.

(*c*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine at a cross-head speed not to exceed $\frac{1}{8}$ in. per min. The tensile strength shall be determined at a cross-head speed not to exceed $1\frac{1}{2}$ in. per min.

Bend Tests

9. (*a*) Bend tests shall be required for castings only when so specified in the purchase order.

(*b*) When a bend test is specified, the test specimens shall stand being bent cold through an angle of 90 deg. around a pin 1 in. in diameter, without cracking on the outside of the bent portion.

Test Specimens

10. (*a*) For castings having a net weight of not over 500 lb., tension test specimens, and, when a bend test is specified, bend test specimens, shall be taken from test bars attached to special blocks. For castings over 500 lb., net weight, the test specimens shall be taken from test bars cast attached to the castings where practicable. If, as agreed upon between the manufacturer and purchaser, the design of the castings is such that test bars attached directly to the castings might injuriously affect the latter or the test specimen, the test bars shall be cast attached to special blocks. Test bars from which tension test specimens are to be taken shall remain attached to the castings or blocks they represent until submitted for inspection, and shall be heat-treated with the castings, unless the purchaser authorizes detachment before treatment. Test bars shall be provided by the manufacturer in sufficient number to furnish all tests required by these specifications or as agreed upon.

(*b*) Tension test specimens shall be machined and shall be of the usual type for 2-in. gage length as described in Section 15 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1] The diameter of the test specimen shall be 0.505 in. The ends shall be of such form to fit the holder of the testing machine in such a way that the load shall be axial.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

Number of Tests

11. One tension test and, when specified, one bend test shall be made from each melt in each heat-treatment charge, and, when specified in the inquiry, from each casting weighing 500 lb. or over.

Retests

12. (*a*) If the results of the tension tests for any lot do not conform to the requirements specified in Section 8 (*a*), such lot may be heat treated again, but not more than twice. Retests shall be made as specified in Section 11.

(*b*) If the percentage of elongation of any tension test specimen is less than that specified in Section 8 (*a*), and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

(*c*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case another specimen from the same melt and heat treatment charge shall be substituted.

Hydrostatic Tests

13. Each casting shall be tested after machining to the hydrostatic pressure specified in the following table and shall show no leaks. Castings ordered under these specifications, for working pressures other than those listed below, shall be tested to such pressures as may be agreed upon by the manufacturer and purchaser:

PRIMARY SERVICE PRESSURE RATING AT 750 F., LB. PER SQ. IN.	STANDARD HYDROSTATIC TEST PRESSURE, LB. PER SQ. IN.
100	350
300	750
400	1000
600	1500
900	2000
1500	3500

Radiographic or Destruction Tests

14. (*a*) When so specified in the purchase order, the purchaser may, at his own expense, examine the castings for internal defects by means of X-ray or gamma-rays of radium, and castings showing injurious defects shall be rejected.

(*b*) Or when so specified in the purchase order, the purchaser may, at his own expense, select representative castings from each melt or heat-treatment charge, and crush or cut up and etch, or otherwise prepare the sections for examination, for internal defects. Should injurious defects be found which evidence unsound steel or faulty foundry technique, all of the castings from that particular pattern, melt and heat-treatment charge may be rejected. All the rejected castings, including those cut up, shall be replaced by the manufacturer, without charge. Coarse-grained fracture or other evidence of improper treatment shall be cause for reheat treating.

Workmanship and Finish

Workmanship

15. The castings shall conform substantially to the shapes and sizes indicated by the drawings approved.

Finish

16. (*a*) The castings shall be clean and free from injurious defects.

(*b*) The castings shall not be peened to stop leaks.

(*c*) Defects which do not impair the strength of the castings may be welded by an approved process. The defects shall be cleaned out to solid metal, before welding, and shall be submitted to the inspector representing the purchaser in this condition for his approval. All castings shall be heat treated after welding in accordance with the requirements of Sections 3 and 4, except that with permission of the inspector, castings with minor welds need only be drawn or tempered. In the case of major repair welds, the inspector may require examination after reannealing with X-rays or gamma-rays to show the adequacy of the repair, the cost of X-raying or gamma-raying to be borne by the manufacturer, notice of such to be given at the time permission is granted to weld.

Marking

Marking

17. Identification marks consisting of the manufacturer's symbol or name, designation of service rating, A 157 with the designation F_1, F_2 or A_1, etc., showing the class of material and the size shall be permanently cast or stamped on each casting in accordance with the Product Marking System (No. SP-25-1934) of the Manufacturers Standardization Society of the Valve and Fittings Industry and in such position as not to injure the usefulness of the casting. In addition, melt number or melt identification shall be indicated.

Inspection and Rejection

Inspection

18. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which con-

cern the manufacture of the castings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) If, in the case of important castings for special purposes, surface inspection in the green state is required, this shall be so specified in the order.

Rejection

19. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 7 shall be reported within twelve working days from receipt of samples.

(*b*) Castings which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected and the manufacturer shall be notified.

Rehearing

20. Samples tested in accordance with Section 7, which represent rejected castings, shall be preserved for two weeks from the date of transmission of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

EXPLANATORY NOTES

NOTE 1.—This contemplates temperatures from 750 to 1100 F. (See the Standard Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A.S.T.M. Designation: A 95) of the American Society for Testing Materials.)[1]

NOTE 2.—The subcommittee formulating these specifications has included eight grades of material that have been rather extensively used for the present purpose. It is not the intent that these specifications should be limited to these eight alloys. Other compositions will be considered for inclusion by the committee from time to time as the need becomes apparent. It should also be noted that it is not intended to imply that all of the alloy steels shown are suitable over the entire temperature range. Some are suitable only at lower temperatures, unless low stresses are employed. Pending the incorporation of high-temperature data in an appendix, which it is the purpose in due time to add, high-temperature properties, when it is desired that the same be indicated or specified, shall be a matter of mutual agreement between the purchaser and the manufacturer. No high-temperature tests shall be required on the materials selected unless a matter of agreement between the purchaser and the manufacturer. When required, the short-time tests at elevated temperatures shall be in accordance with the Tentative Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials (A.S.T.M. Designation: E 21 - 34 T) and the creep tests shall be in accordance with the Tentative Method of Test for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials (A.S.T.M. Designation: E 22 - 34 T) of the American Society for Testing Materials.[1]

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 259.

---

[1] See pp. 1214 and 1223.

TENTATIVE SPECIFICATIONS

FOR

SEAMLESS ALLOY-STEEL PIPE FOR SERVICE AT TEMPERATURES FROM 750 TO 1100 F.[1]

A.S.T.M. Designation: A 158 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Scope

1. (*a*) These specifications are intended as a general guide for the purchase of alloy-steel pipe and to serve as a basis for agreement between purchaser and manufacturer as to details not specifically covered.

(*b*) These specifications cover seamless alloy-steel pipe intended for service at metal temperatures from 750 to 1100 F.; both ferritic steels designated F_1, F_2, F_3, etc., and austenitic steels designated A_1, A_2, A_3, etc., are included (Note 1). The maximum temperature at which the pipe will be operated in service shall be stated in the purchase order. Choice from the respective steels should be made on the basis of the requirements of design, service conditions, and the physical properties (Note 2). Supplementary requirements (Paragraphs S1 to S6) of an optional nature are provided for pipe intended for use in central stations having steam service pressures of 400 lb. per sq. in. or over and temperatures up to 1100 F., or other applications where a superior grade of pipe is required. These supplementary requirements call for additional tests to be made at the expense of the purchaser, and when desired shall be so stated in the order.

Certification

2. Where mutually agreed upon in writing between the manufacturer and purchaser, a certification that the material conforms to the requirements of these specifications shall be the basis of accept-

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

ance of the material. Otherwise, the manufacturer shall report to the purchaser or his representative the results of the chemical analyses and tension tests made in accordance with these specifications.

MANUFACTURE

Process

3. (*a*) The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

(*b*) Unless otherwise specified, all pipe 2 in. and over in nominal diameter shall be furnished hot-finished followed by the treatment specified in Section 5.

(*c*) Unless otherwise specified, pipe under 2 in. in nominal diameter may be furnished either hot-finished or cold-drawn, with, where necessary, a suitable manufacturer's finishing treatment.

Discard

4. Sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

Heat Treatment

5. (*a*) All ferritic steels other than those covered in Section 3 (*c*) shall be furnished in a full-annealed or normalized and drawn condition as stated in the purchase order. If tested in the normalized and drawn condition, the temperature for drawing shall be at least 200 F. above the service temperature as given in the purchase order.

(*b*) All austenitic steels shall be stabilized according to present accepted practice.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

6. Each alloy shall conform to the following chemical requirements, or to other chemical requirements as specified in the purchase order:

Class	Ferritic Steels							
Grade	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8
	Chromium-Molybdenum	Chromium-Molybdenum	Chromium	Chromium-Molybdenum	Chromium-Tungsten	Molybdenum	Manganese-Molybdenum	Nickel-Molybdenum
Carbon, per cent	0.10 to 0.20	0.10 to 0.20	0.10 to 0.20	0.10 to 0.20	0.10 to 0.20	0.10 to 0.20	0.10 to 0.20	0.10 to 0.20
Manganese, per cent	0.30 to 0.50	0.40 to 0.60	0.50 max.	0.50 max.	0.50 max.	0.30 to 0.60	1.10 to 1.40	0.30 to 0.60
Silicon, per cent	0.75 to 1.25	0.45 to 0.75	0.50 max.	0.50 max.	0.50 max.	0.20 to 0.50	0.20 to 0.50	0.50 max.
Sulfur, per cent	0.03 max.	0.04 max.	0.03 max.	0.03 max.	0.03 max.	0.045 max.	0.045 max.	0.045 max.
Phosphorus, per cent	0.03 max.	0.03 max.	0.03 max.	0.03 max.	0.03 max.	0.04 max.	0.04 max.	0.04 max.
Chromium, per cent	1.00 to 1.50	1.50 to 2.00	4.00 to 6.00	4.00 to 6.00	4.00 to 6.00	....	....	....
Molybdenum, per cent	0.40 to 0.60	0.60 to 0.80	....	0.45 to 0.65	....	0.45 to 0.65	0.20 to 0.30	0.20 to 0.30
Tungsten, per cent	....	....	....	....	0.75 to 1.25	....	....	....
Nickel, per cent	....	....	....	....	....	....	....	1.50 to 2.00

Class	Austenitic Steels			
Grade	A_1	A_2	A_3	A_4
	....	....	....	Chromium-Tungsten
Carbon, per cent	0.07 max.	0.16 max.	0.25 max.	0.12 max.
Manganese, per cent	0.20 to 0.70	0.20 to 0.70	0.50 to 0.70	0.50 max.
Silicon, per cent	0.70 max.	0.70 max.	1.00 to 3.00	0.50 max.
Sulfur, per cent	0.03 max.	0.03 max.	0.03 max.	0.025 max.
Phosphorus, per cent	0.03 max.	0.03 max.	0.03 max.	0.025 max.
Chromium, per cent	17.00 to 19.00	17.00 to 19.00	17.00 to 19.00	12.00 to 15.00
Molybdenum, per cent	....	....	....	....
Tungsten, per cent	....	....	....	2.50 to 3.50
Nickel, per cent	7.00 to 9.00	7.00 to 9.00	8.00 to 10.00	....

Ladle Analysis

7. A ladle analysis of each melt of steel shall be made by the steel manufacturer. The chemical composition thus determined, or that determined from a check analysis made by the pipe manufacturer, if the latter has not manufactured the steel, shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 6.

Check Analysis

8. (*a*) At the request of the purchaser's inspector, analyses as specified below shall be made by the manufacturer from the finished pipe and shall conform to the requirements specified in Section 6:

NOMINAL DIAMETER	NUMBER OF PIPES SELECTED
Under 2 in.	2 pipes from each lot of 400 lengths or fraction thereof
2 to 5 in. inclusive	2 pipes from each lot of 200 lengths or fraction thereof
6 in. and over	2 pipes from each lot of 100 lengths or fraction thereof

Results of these analyses shall be reportd to the purchaser or his representative and shall conform to the requirements specified in Section 6.

(*b*) Drillings for analysis shall be taken from several points around each pipe selected for analysis.

(*c*) If the analysis of one of the tests specified in Section 7 or 8 (*a*) does not conform to the requirements specified in Section 6, analysis of each billet or pipe from the same heat or lot may be made, and all billets or pipe conforming to the requirements shall be accepted. When drillings for analysis are taken from the billet, the sample shall be taken at a point midway between the outside and center of the piece by drilling parallel to the axis.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

9. (*a*) The material shall conform to the following minimum requirements as to tensile properties at room temperature:

	FERRITIC STEELS	AUSTENITIC STEELS
Tensile strength, lb. per sq. in.	60 000[a]	75 000[a]
Yield point, lb. per sq. in.:		
Fully annealed	25 000[a]	......
Normalized and drawn	30 000[a]	......
Rapidly air-cooled or quenched	......	30 000[a]
Elongation in 2 in., per cent	30[a]	50[a]

[a] For transverse tension tests the material shall conform to these minimum tensile requirements except that the elongation in 2 in. shall be 25 per cent for the ferritic steels and 40 per cent for the austenitic steels.

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or by the use of dividers or other approved method, at a cross-head speed not to exceed $\frac{1}{8}$ in. per minute. Where a definite yield point is not exhibited, the yield strength, corresponding to a limiting permanent set of 0.2 per cent of the gage length of the specimen, shall be reported instead. The "set method" of determining yield strength as described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials[1] shall be followed. The tensile strength shall be determined at a crosshead speed not to exceed $1\frac{1}{2}$ in. per minute.

Hydrostatic Tests

10. (*a*) Unless otherwise mutually agreed upon between the manufacturer and purchaser, each length of pipe shall be tested by the manufacturer to a hydrostatic pressure which will produce in the pipe wall a stress of 50 per cent of the minimum specified yield point at room temperature. This pressure shall be determined by the formula:

$$P = \frac{2St}{D}$$

where P = the minimum hydrostatic test pressure in pounds per square inch;

S = 0.50 times the minimum specified yield point at room temperature in pounds per square inch;

t = the nominal wall thickness in inches; and

D = the outside diameter in inches.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

(*b*) The maximum hydrostatic test pressure shall not exceed 2500 lb. per sq. in. for sizes 3 in. or under in outside diameter, nor 4500 lb. per sq. in. for sizes over 3 in. in outside diameter. The hydrostatic pressure shall be maintained for not less than 5 sec.

Flattening Tests

11. For pipe over 2 in. in nominal diameter, a section of pipe not less than 2½ in. in length shall be flattened between parallel plates until the opposite walls of the pipe meet. No cracks or breaks in the metal shall occur until the distance between the plates is less than one half the outside diameter of the pipe, but in no case less than seven times the thickness of the pipe wall. Evidence of laminations or burnt material shall not develop during the entire flattening process.

Bend Tests

12. For pipe 2 in. or under in nominal diameter, a sufficient length of pipe shall stand being bent cold through 90 deg. around a cylindrical mandrel, the diameter of which is twelve times the nominal diameter of the pipe, without developing cracks. When ordered for close coiling, the pipe shall stand being bent cold through 180 deg. around a cylindrical mandrel, the diameter of which is eight times the nominal diameter of the pipe, without failure.

Test Specimens

13. (*a*) Specimens cut either longitudinally or transversely shall be acceptable for tension tests.

(*b*) Longitudinal tension tests may be made in full section of the pipe up to the capacity of the testing machine. For larger sizes, the tension test specimens shall consist of strips cut from the pipe. The width of these specimens shall be 1½ in. and shall have a gage length of 2 in. When the pipe wall thickness exceeds ¾ in., the A.S.T.M. standard 0.505-in. round specimen shall be used (Note). Longitudinal tension specimens shall not be flattened between gage marks. The sides of specimens shall be parallel between gage marks.

(*c*) The transverse tension test may be made on pipe 8 in. and over in nominal diameter. Specimens may be taken from a ring cut from the pipe or from sections resulting from the flattening tests. The specimen shall consist of a strip cut transversely from the pipe; the width of the specimen shall be 1½ in. and its gage length 2 in. When the pipe wall thickness exceeds ¾ in., the A.S.T.M. standard 0.505-in. round specimen shall be used (Note). Specimens shall be flattened cold and shall be parallel between gage marks. At the option of the manufacturer, the transverse tension test specimen may be machined off on either surface provided not over 15 per cent of the nominal thickness is removed from either side.

NOTE.—The standard tension test specimens are described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

(*d*) Test specimens for flattening and bend tests shall consist of sections cut from a pipe. Specimens for flattening tests shall be smooth on the ends and free from burrs, except when made on crop ends.

(*e*) All routine check tests shall be made at room temperature.

Number of Tests

14. (*a*) Tests shall be made as follows on one pipe from each heat-treated lot, but in no case on less than 5 per cent of the pipe ordered. Results of these tests shall be reported to the purchaser or his representative:

One transverse or longitudinal tension test specified in Section 9.

The flattening test specified in Section 11 for pipe over 2 in. in nominal diameter.

The bend test specified in Section 12 for pipe 2 in. or under in nominal diameter.

(*b*) For material heat treated by the continuous process, the tests specified in Section 14 (*a*) shall be made on each pipe in a lot constituting 5 per cent of the pipe ordered, but on not less than two pipes.

(*c*) Each length of pipe shall be subjected to the hydrostatic test specified in Section 10.

Retests

15. (*a*) If the results of any chemical or physical tests of any lot do not conform to the requirements specified in Sections 8 (*a*), 9, 11, or 12, retests shall be made on additional pipes of double the original number from the same lot, each of which shall conform to the requirements specified.

(*b*) If the percentage of elongation of any tension test specimen is less than that specified and any part of the fracture is more than ¾ in. from the center of the gage length of the specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed. If a specimen breaks in an inside or outside surface flaw, a retest shall be allowed.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

(*c*) If any specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

Retreatment

16. If individual lengths of pipe selected to represent any lot fail to meet the test requirements of Sections 9, 11, or 12, the lot may be heat treated again and resubmitted for test, except that any individual lengths which meet the test requirements before retreating will be acceptable.

WEIGHTS, DIMENSIONS, AND PERMISSIBLE VARIATIONS

Permissible Variations in Weight and Dimensions

17. (*a*) *Weight.*—The weight of any length of pipe in sizes up to and including 12 in. shall not vary more than 3.5 per cent under and 6.5 per cent over that specified. For sizes over 12 in. the weight of any length shall not vary more than 5 per cent under and 10 per cent over that specified. Unless otherwise mutually agreed upon between the manufacturer and purchaser, pipe in sizes smaller than 4 in. may be weighed in convenient lots; pipe in sizes 4 in. and larger shall be weighed separately.

(*b*) *Diameter.*—Variations in outside diameter shall not exceed those shown in the following table:

NOMINAL DIAMETER	PERMISSIBLE VARIATIONS IN OUTSIDE DIAMETERS UNDER	 OVER
$\frac{1}{8}$ to $1\frac{1}{2}$ in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{1}{64}$ in. (0.015 in.)
2 to 4 in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{1}{32}$ in. (0.031 in.)
5 to 8 in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{1}{16}$ in. (0.062 in.)
10 to 18 in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{3}{32}$ in. (0.093 in.)
20 to 24 in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{1}{8}$ in. (0.125 in.)

(*c*) *Thickness.*—The minimum wall thickness at any point shall not be more than 12.5 per cent under the nominal wall thickness specified.

(*d*) *Length.*—Pipe lengths shall be in accordance with the following regular practice:

> The lengths required shall be specified in the order. No pipe shall be under the specified length and not more than $\frac{1}{4}$ in. over that specified.
>
> No jointers are permitted unless otherwise specified.

WORKMANSHIP AND FINISH

Ends

18. Unless otherwise specified, pipe shall be furnished with plain ends. All burrs at the ends of the pipe shall be removed.

Finish

19. (*a*) The finished pipe shall be reasonably straight and free from injurious defects, and shall have a workmanlike finish.

Depth of Injurious Defects

(*b*) When the depth of defect in the pipe encroaches on the minimum wall thickness (87.5 per cent of the nominal thickness), or is in excess of 12.5 per cent of the nominal wall thickness, such defects shall be considered injurious.

Machining or Grinding Defects

(*c*) Pipe showing moderate slivers may be machined or ground inside or outside to a depth which shall insure the removal of all included scale and slivers, providing the wall thickness is not reduced below the minimum wall thickness required in these specifications. Machining or grinding shall follow inspection of the pipe as rolled, and shall be followed by supplementary visual inspection.

Repair by Welding

(*d*) Repair of injurious defects shall be permitted only subject to the approval of the purchaser and with the further understanding that the composition of the welding rod shall be suitable for the composition of the metal being welded. Welding of injurious defects in no case shall be permitted when the depth of defect exceeds $33\frac{1}{3}$ per cent of the nominal pipe wall thickness or the length of repair exceeds 25 per cent of the nominal diameter of the pipe. Defects shall be thoroughly chipped out before welding, and then heat treated in accordance with Section 5. Each length of repaired pipe shall be retested hydrostatically in accordance with Section 10.

Marking

20. Each length of pipe manufactured in accordance with these specifications shall be legibly marked, either by stenciling, stamping, or rolling, with the manufacturer's private identifying mark, together with the symbols A 158 and the alloy symbol (as A $158 - F_1$) and an additional S if pipe meets the supplementary requirements specified in Paragraphs S1 to S7. Marking shall be within 12 in. of one end of each length. On pipe sizes 4 in. and larger, the weight shall be given. On small diameter pipe which is bundled, the above information may be legibly stamped on a metal tag securely attached to each bundle. When pipe marked as specified in this section is rejected, the designation A 158 shall be canceled.

INSPECTION AND REJECTION

Inspection

21. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment and at the manufacturer's expense, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

22. Each length of pipe which develops injurious defects in shop working or application shall be rejected, and the manufacturer shall be notified. No rejections under these or any other specifications, shall be marked as specified in Section 20 for sale under these specifications except where such pipe fails to comply with the weight requirements alone, in which case it may be sold under the weight specifications with which it does comply.

Supplementary Requirements Appear on Pages 626 and 627.

SUPPLEMENTARY REQUIREMENTS FOR SEAMLESS PIPE FOR USE IN CENTRAL STATIONS AT PRESSURES OF 400 LB. PER SQ. IN., OR OVER, AND TEMPERATURES OF 750 F. TO 1100 F., OR OTHER APPLICATIONS WHERE A SUPERIOR GRADE OF PIPE IS REQUIRED

S1. These requirements shall not be considered unless specified in the order, in which event the supplementary tests shall be made at the mill, unless otherwise agreed upon, at the purchaser's expense and witnessed by his inspector before shipment of the material.

Check Analysis

S2. Check analysis may be made on any length of pipe. Individual lengths failing to meet the chemical requirements specified in Section 6 shall be rejected.

Transverse Tension Tests

S3. Transverse tension tests may be made on specimens from both ends of each length of pipe. If the specimen from either end of any length fails to meet the physical properties specified in Section 9, that length shall be rejected.

Flattening Tests

S4. The flattening tests specified in Section 11 may be made on specimens from both ends of each length of pipe. Crop ends may be used. If the specimen from either end of any length fails to meet the specified requirements, that length shall be rejected.

Finish and Metal Structure

S5. The finished pipe shall be free from all immoderate slivers and depressions. The steel shall have a homogeneous structure as shown by the etching test in Paragraph S6.

Etching Tests

S6. Etching tests[1] may be made on sections from any pipe, and shall show sound and reasonably uniform material, free from injurious laminations, cracks and similar objectionable defects. Sections used for the flattening tests described in Section 11 may be used for the etching test. If the specimen from any length shows objectionable defects, that length may be rejected.

---

[1] Pending development of etching methods applicable to the product covered by these specifications, it is recommended the Tentative Recommended Practice for a Standard Macro-Etch Test for Steel described in the *National Metals Handbook*, Am. Soc. for Metals, 1933 edition, p. 639, be followed.

Rejection

S7. At the purchaser's discretion, if 10 per cent of the pipe in any one lot fail to meet the requirements of Paragraphs S2 to S6, the entire lot may be rejected. Rejection of a lot shall be based on tests from not less than two pipes. A lot shall consist of all the pipe bought by a purchaser of the same size and wall thickness from any one heat.

EXPLANATORY NOTES

NOTE 1.—The subcommittee formulating these specifications has included several classes of material that have been rather extensively used. Upon mutual agreement between the manufacturer and purchaser, other classes of material may be employed, provided they otherwise meet the requirements of these specifications. Other compositions will be considered for inclusion in these specifications by the committee from time to time as the need becomes apparent.

NOTE 2.—Pending the incorporation of high-temperature data in an appendix, which it is the purpose in due time to add, high-temperature properties, when it is desired that the same be indicated or specified, shall be a matter of agreement between the manufacturer and purchaser. No high-temperature tests shall be required on the materials selected unless a matter of agreement between the manufacturer and purchaser. When required, the short-time tests at elevated temperature shall be in accordance with the Tentative Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials (A.S.T.M. Designation: E 21 - 34 T) and the creep tests shall be in accordance with the Tentative Method of Test for Long-Time (Creep) High-Temperature Tension Tests of Metallic Materials (A.S.T.M. Designation: E 22 - 34 T) of the American Society for Testing Materials.[1]

---

[1] See pp. 1214 and 1223.

TENTATIVE SPECIFICATIONS

FOR

ELECTRIC-FUSION-WELDED STEEL PIPE FOR HIGH-TEMPERATURE AND HIGH-PRESSURE SERVICE[1]

A.S.T.M. Designation: A 155 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. (*a*) These specifications cover electric-fusion-welded steel pipe 18 in. in outside diameter and over, for high-temperature and high-pressure service (Note 1). Pipe ordered under these specifications shall be suitable for bending, flanging, corrugating, and similar forming operations (Note 2). Supplementary requirements (Paragaraphs S1 to S6) of an optional nature are provided for pipe intended for use in central stations having steam service pressures of 400 lb. per sq. in. or over and temperatures up to 850 F., or other applications where these additional requirements are considered desirable. These supplementary requirements call for additional tests to be made at the expense of the purchaser, and when desired shall be so stated in the order.

(*b*) Preparation for welding, type of welded joint, physical tests of the weld (including tension, bend, and specific gravity tests), radiographic examination, and stress relieving shall be in accordance with the requirements governing welding of Class 1 fusion-welded vessels of the A.S.M.E. Rules for Construction of Unfired Pressure Vessels.[2] Stress relieving shall precede any radiographic examination of the weld.

MANUFACTURE

Process

2. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

[2] Boiler Construction Code, Am. Soc. Mechanical Engrs., Section VIII, latest edition.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. The steel shall conform to the following requirements as to chemical composition:

		GRADE A	GRADE B	GRADE C
Carbon, max., per cent	For plate ¾ in. or under in thickness	0.15	0.20	0.25
	For plate over ¾ in. in thickness	0.17	0.22	0.30
Manganese, per cent		0.35 to 0.60	0.35 to 0.60	0.30 to 0.60
Phosphorus, max., per cent	Acid	0.05	0.05	0.05
	Basic	0.04	0.04	0.04
Sulfur, max., per cent		0.05	0.05	0.05

Ladle Analyses

4. An analysis of each melt of steel shall be made by the plate manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. When requested by the purchaser of the pipe, the chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the specified requirements.

Check Analyses

5. (*a*) For each lot of 500 ft. of pipe or fraction thereof, analyses shall be made by the manufacturer from the finished pipe and shall conform to the requirements specified in Section 3. The results of these analyses shall be reported to the purchaser or his representative.

(*b*) Drillings for analysis shall be taken from several points around the section of the pipe selected for tension tests of the plate.

PHYSICAL PROPERTIES AND TESTS

Physical Properties

6. (*a*) The plate used for making the pipe shall conform to the following minimum requirements as to tensile properties:

	GRADE A	GRADE B	GRADE C
Tensile strength, lb. per sq. in.	45 000	50 000	55 000
Yield point, lb. per sq. in.	0.5 tens. str.	0.5 tens. str.	0.5 tens. str.
but in no case less than	24 000	27 000	....
Elongation in 8 in., per cent[a]	$\frac{1\,500\,000}{\text{tens. str.}}$	$\frac{1\,500\,000}{\text{tens. str.}}$	$\frac{1\,500\,000}{\text{tens. str.}}$

---

[a] See Paragraph (*c*).

(*b*) The yield point of the specimen taken from the plate material of a finished pipe shall be determined by the drop of the beam or halt in the gage of the testing machine at a cross-head speed of not to exceed $\frac{1}{8}$ in. per minute.

(*c*) For material over $\frac{3}{4}$ in. in thickness, a deduction from the percentage of elongation specified in Paragraph (*a*) of 0.125 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness above $\frac{3}{4}$ in., to a minimum of 20 per cent.

(*d*) When requested by the purchaser of the pipe, the physical properties of the plate as reported by the plate manufacturer shall be reported to the purchaser or his representative and shall conform to the requirements specified in Paragraph (*a*).

(*e*) Physical tests of the weld in the finished pipe shall be made by the manufacturer, as specified for Class 1 fusion-welded vessels of the A.S.M.E. Rules for Construction of Unfired Pressure Vessels.[1]

Bend Tests

7. The bend test specimen shall be taken transversely from the plate material of a finished pipe and shall stand being bent cold in the opposite direction to its initial curvature through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in nominal thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1 in. in nominal thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

Hydrostatic Tests

8. (*a*) Unless otherwise mutually agreed upon between the manufacturer and purchaser, each length of pipe shall be tested by the manufacturer to a hydrostatic pressure which represents a stress of 75 per cent of the minimum specified yield point. This pressure shall be determined by the formula:

$$P = \frac{2\,St}{D}$$

where P = the minimum hydrostatic test pressure in pounds per square inch;

S = 0.75 × the minimum specified yield point in pounds per square inch;

t = the specified pipe wall thickness in inches; and

D = the inside diameter of the pipe in inches, or the outside diameter in inches if the specified pipe wall thickness exceeds 5 per cent of the inside diameter.

---

[1] Boiler Construction Code, Am. Soc. Mechanical Engrs., Section VIII, latest edition.

(*b*) While under pressure, each pipe shall be struck at 6-in. intervals on both sides of the weld and for its full length by a hammer whose weight in pounds shall approximately equal the pipe wall thickness in tenths of an inch, but not to exceed 10 lb. The pipe shall be struck with sharp swinging blows, but without indenting or otherwise injuring the plate surface.

Test Specimens

9. (*a*) Tension test and transverse bend test specimens of the plate shall be taken from the end of the finished pipe at a point not less than 90 deg. from the weld. The tension test specimen may be taken transversely, if desired, except that an elongation of 5 per cent less than specified for the longitudinal specimen will be acceptable. The longitudinal tension test specimen shall not be flattened between gage marks; the transverse specimen shall be flattened cold.

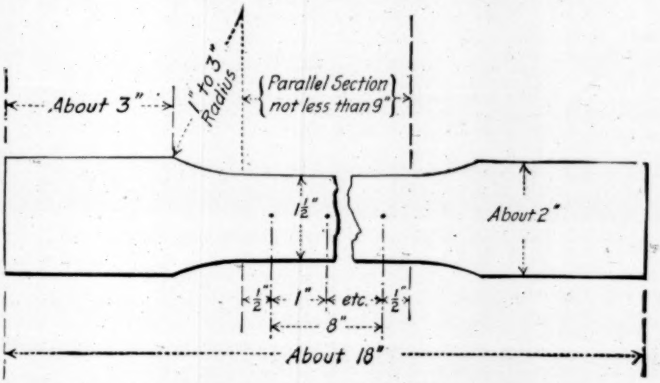


FIG. 1.—Standard 8-in. Gage Length Test Specimen.

(*b*) Tension and bend test specimens shall be of the full thickness of the material as rolled, and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel.

(*c*) The weld test specimens, described in the A.S.M.E. Rules for Construction of Unfired Pressure Vessels, shall be taken from a pipe end, or a flat welded test plate made from material conforming to the requirements of these specifications, and shall be welded in the same way and by the same operator and equipment as the longitudinal joints in the pipe. The test plate, either cut from a length of pipe or separately made, shall be straightened cold and then stress relieved. The stress-relieving operation shall be the same as that required for the pipe. At no time shall the test plates be heated to a temperature higher than that used for stress relieving.

(*d*) All specimens shall be tested at atmospheric temperature.

Number of Tests

10. (*a*) For each lot of 500 ft. of pipe or fraction thereof, one tension test, either longitudinal or transverse (Section 9 (*a*)), and one transverse bend test of the plate shall be made from the end of one of the pipe lengths in that lot.

(*b*) For each 200 ft. of weld or fraction thereof, one welded test plate shall be prepared and specimens therefrom shall be used for the physical tests of the weld specified for Class 1 fusion-welded vessels of the A.S.M.E. Rules for Construction of Unfired Pressure Vessels[1] as stated in Section 1 (*b*).

(*c*) Each length of finished pipe shall be subjected to the hydrostatic test specified in Section 8.

TABLE I.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over	
Under $\frac{1}{8}$	9	10	12	14	..	..	..	..	..	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$ excl.	8	9	10	12	..	..	..	..	..	$\frac{1}{8}$ to $\frac{3}{16}$ excl.
$\frac{3}{16}$ " $\frac{1}{4}$ "	7	8	9	10	12	..	..	..	..	$\frac{3}{16}$ " $\frac{1}{4}$ "
$\frac{1}{4}$ " $\frac{5}{16}$ "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ " $\frac{5}{16}$ "
$\frac{5}{16}$ " $\frac{3}{8}$ "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ " $\frac{3}{8}$ "
$\frac{3}{8}$ " $\frac{7}{16}$ "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ " $\frac{7}{16}$ "
$\frac{7}{16}$ " $\frac{1}{2}$ "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ " $\frac{1}{2}$ "
$\frac{1}{2}$ " $\frac{5}{8}$ "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ " $\frac{5}{8}$ "
$\frac{5}{8}$ " $\frac{3}{4}$ "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ " $\frac{3}{4}$ "
$\frac{3}{4}$ " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ " 1 "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

NOTE.—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third the amount given in this table.

Retests

11. (*a*) If the results of any chemical or physical tests of pipe material of any lot do not conform to the requirements specified in Sections 3, 5, 6 and 7, retests shall be made on specimens from additional pipe of double the original number from the same lot, each of which shall conform to the requirements specified.

(*b*) Retests for weld material failing to meet the requirements shall be as specified for Class 1 fusion-welded vessels of the A.S.M.E. Rules for Construction of Unfired Pressure Vessels.[1]

(*c*) If any specimen shows defective machining or develops flaws not associated with the welding, it may be discarded and another specimen substituted. If a specimen breaks in an outside or inside surface flaw in the plate, a new test shall be allowed.

---

[1] Boiler Construction Code, Am. Soc. Mechanical Engrs., Section VIII, latest edition.

WEIGHTS, DIMENSIONS AND PERMISSIBLE VARIATIONS

Thicknesses and Weights

12. The wall thicknesses and weights for welded pipe under these specifications shall be governed by the requirements of the specifications to which the manufacturer ordered the plate, except that permissible overweights of plates ordered to thickness shall not exceed the values given in Table I.

Permissible Variations

13. (*a*) Permissible variations in dimensions at any point in a length of pipe shall not exceed: (*1*) for outside diameter, based on circumferential measurement, ±0.5 per cent of the nominal outside diameter; (*2*) for out of roundness, that is, difference between major and minor outside diameters, 1 per cent; (*3*) for alignment, using a 10-ft. straight edge placed so that both ends are in contact with the pipe, $\frac{1}{8}$ in.

(*b*) The minimum wall thickness at any point in the pipe shall not be more than 0.01 in. under the nominal thickness.

Lengths

14. Pipe lengths shall be in accordance with the following regular practice:

(*a*) The lengths required shall be specified in the order;

(*b*) Circumferentially welded joints of the same quality as the longitudinal joints shall be allowed by mutual agreement between the manufacturer and purchaser.

WORKMANSHIP AND FINISH

Ends

15. Unless otherwise specified, pipe shall be furnished with plain ends. All burrs at the ends of the pipe shall be removed.

Metal Structure Finish

16. (*a*) The finished pipe shall be free from injurious defects, and shall have a workmanlike finish.

Machining or Grinding Defects

(*b*) Pipe showing moderate slivers may be machined or ground inside or outside to a depth which shall insure the removal of all included scale and slivers, providing the wall thickness is not reduced below the specified minimum wall thickness. Machining or grinding shall follow inspection of the pipe as rolled, and shall be followed by supplementary visual inspection.

Repair by Welding

(*c*) Repair of injurious defects shall be permitted only subject to the approval of the purchaser. Defects shall be thoroughly chipped out before welding. The repairs shall be radiographed and, if the pipe itself has already been stress relieved, it shall then be stress relieved again except in the case of small welds which in the estimation of the purchaser's inspector do not require stress relief. Hydrostatic tests made on pipe repaired in this manner shall be made on the finished pipe.

MARKING

Marking

17. Each length of pipe manufactured in accordance with these specifications shall be legibly marked, either by stenciling, stamping, or rolling, with the manufacturer's private identifying mark, together with the symbols A 155-A (B or C, depending on the grade of steel used) and an additional S if the pipe meets the supplementary requirements specified in Sections 20 to 22. Marking shall be within 12 in. of one end of each length. When pipe marked as specified in this section is rejected, the designation A 155 shall be canceled.

INSPECTION AND REJECTION

Inspection

18. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment and at the manufacturer's expense, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

19. Material which shows injurious defects subsequent to acceptance at the manufacturer's works or within one year after shipment from the manufacturer's works, may be rejected and the manufacturer shall be notified. No rejections, under these or any other specifications, shall be marked as specified in Section 17 for sale under these specifications except where such pipe fails to comply with the weight specifications alone, in which case it may be sold under the weight specifications with which it does comply.

SUPPLEMENTARY REQUIREMENTS FOR PIPE FOR USE IN CENTRAL STATIONS AT PRESSURES OF 400 LB. PER SQ. IN. OR OVER AND TEMPERATURES UP TO 850 F., OR OTHER APPLICATIONS WHERE A SUPERIOR GRADE OF PIPE IS REQUIRED

S1. The requirements in Paragraphs S1 to S6 in addition to those previously specified apply to pipe for use in central stations at pressures of 400 lb. per sq. in. or over and temperatures up to 850 F., or other applications where a superior grade of pipe is required. *These requirements shall not be considered unless specified in the order*, in which event all tests shall be made at the mill at the purchaser's expense and witnessed by his inspector before shipment of the material.

Check Analysis

S2. Check analysis may be made on any length of pipe. Individual lengths failing to meet the chemical requirements specified in Section 3 shall be rejected.

Tension and Bend Tests

S3. Tension tests and bend tests of the plate and of the welded joint may be made on specimens from both ends of each length of pipe. Tension test specimens may be taken either longitudinally or transversely from the plate material of the finished pipe. If the specimen from either end of any length fails to meet the physical properties specified in these specifications, that length shall be rejected except that a transverse elongation of 5 per cent less than that specified for the longitudinal tension specimen will be acceptable.

Finish and Metal Structure

S4. The finished pipe shall be free from all immoderate slivers and depressions. The steel shall have a homogeneous structure as shown by the etching test of Paragraph S5. Welds shall be chipped flush with the plate surface on the inside of the pipe.

Etching Tests

S5. Etching tests[1] may be made on sections from any pipe, and shall show sound and reasonably uniform material, free from injurious laminations, cracks and similar objectionable defects. Specimens used for the bend test described in Section 7 may be used for the etching test. If the specimen from any length shows objectionable defects, that length may be rejected.

---

[1] Pending development of etching methods applicable to the product covered by these specifications, it is recommended that the Tentative Recommended Practice for a Standard Macro-Etch Test for Steel, described in the *National Metals Handbook*, Am. Soc. for Metals, 1933 edition, p. 639, be followed.

Rejection

S6. At the purchaser's discretion, if 10 per cent of the pipes in any one lot fail to meet the requirements of Paragraphs S2 to S5, the entire lot may be rejected. Rejection of a lot shall be based on tests from not less than two pipes. A lot shall consist of all the pipes bought by a purchaser of the same size and wall thickness from any one heat.

EXPLANATORY NOTES

NOTE 1.—This contemplates, in particular, pipe subjected to pressures above 250 lb. per sq. in. and temperatures from 450 to 850 F., or at the discretion of the designing engineer, higher temperatures with appropriate working stresses may be used. This also contemplates pipe carrying liquids materially above their boiling temperature at atmospheric pressure, as well as all liquids and gases of a lethal nature, at any pressure or temperature. Recommended working stresses for pipe made in accordance with these specifications are given in the following Table II, which correspond to the S-values given in Paragraph 122 of Section 1 of the Proposed Code for Pressure Piping, prepared by Sectional Committee B31 on Code for Pressure Piping, functioning under the procedure of the American Standards Association, and also as given in Paragraph P23 of the A.S.M.E. Boiler Construction Code:

TABLE II.—RECOMMENDED WORKING STRESSES FOR ELECTRIC-FUSION-WELDED STEEL PIPE FOR HIGH-TEMPERATURE AND HIGH-PRESSURE POWER-PIPING SERVICE.

TEMPERATURES IN DEG. FAHR. NOT EXCEEDING	RECOMMENDED WORKING STRESSES, LB. PER SQ. IN. GRADE A (TENS. STR. 45,000)	GRADE B (TENS. STR. 50,000)	GRADE C (TENS. STR. 55,000)
700	8100	9000	9900
750	7400	8200	9000
800	5900	6600	7200
850	4900	5450	6070

NOTE 2.—The purpose for which the pipe is used shall be stated on the face of the order.

TENTATIVE SPECIFICATIONS
FOR
LAP-WELDED AND SEAMLESS STEEL PIPE FOR HIGH-TEMPERATURE SERVICE[1]

A.S.T.M. Designation: A 106 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued as Tentative, 1926; Adopted in Amended Form, 1929;
Reissued as Tentative, 1933; Revised, 1934.[2]

Scope

1. These specifications cover lap-welded and seamless steel pipe for high temperatures (Note 1). Pipe ordered under these specifications shall be suitable for bending, flanging and similar forming operations (Note 2). Supplementary requirements (Paragraphs S1 to S7) of an optional nature are provided for seamless pipe intended for use in central stations having steam service pressures of 400 lb. per sq. in. or over and metal temperatures up to 850 F., or other applications where a superior grade of pipe is required. These supplementary requirements call for additional tests to be made at the expense of the purchaser, and when desired shall be so stated in the order.

Manufacture

Process

2. (*a*) The steel for lap-welded pipe shall be of good weldable quality made by the open-hearth process. The steel for seamless pipe may be made by either or both of the following processes: open-hearth or electric-furnace.

(*b*) Welded pipe 2 in. or over in nominal diameter shall be made by the lap-weld process. All pipe 1½ in. or under in nominal diameter shall be made by the seamless process, and may be either hot finished or cold drawn and annealed.

(*c*) Unless otherwise specified, seamless pipe 2 in. or over in nominal diameter shall be furnished hot finished. When mutually agreed upon between the manufacturer and purchaser, cold drawn and annealed pipe may be furnished.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel.

These specifications are in effect a revision of, and replace the former Standard Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A.S.T.M. Designation: A 106 - 29), which standard was accordingly discontinued in 1933.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. The steel for welded and seamless pipe shall conform to the following ladle analysis requirements as to chemical composition:

	WELDED	SEAMLESS		
	OPEN HEARTH	GRADE A	GRADE B	GRADE C
Manganese, per cent ...	0.30 to 0.60	0.30 to 0.60	0.35 to 1.50	0.35 to 1.50
Phosphorus, max., per cent................	0.045	0.04	0.04	0.04
Sulfur, max., per cent ..	0.06	0.06	0.06	0.06
Carbon, max., per cent.	....	....	0.40[a]	[a]

[a] In case grade B or C pipe is to be joined by fusion welding, the purchaser may wish to stipulate the carbon content by special agreement; see recommendations included in the List of Specifications for Steel Suitable for Fusion Welding (A.S.T.M. Designation: A 151) of the American Society for Testing Materials.[1]

Check Analysis

4. (*a*) At the request of the purchaser's inspector, analyses of two pipes from each lot of 400 lengths or fraction thereof of each size 2 in. up to, but not including, 6 in., and from each lot of 200 lengths or fraction thereof of each size 6 in. or over, shall be made by the manufacturer from the finished pipe and shall conform to the requirements specified in Section 3.

(*b*) Drillings for analysis shall be taken from several points around each pipe selected for analysis.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

5. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

	WELDED	SEAMLESS		
	OPEN HEARTH	GRADE A (NOTE 2)	GRADE B	GRADE C
Tensile strength, lb. per sq. in..........	45 000	48 000[a]	62 000[a]	75 000[a]
Yield point, lb. per sq. in...............	25 000	30 000[a]	35 000[a]	45 000[a]
Elongation in 8 in., per cent...........	22	......	......	......
Elongation in 2 in., per cent	......	35[a]	25[a]	20[a]

[a] For transverse tension tests, the material shall conform to these minimum tensile requirements except that the elongation in 2 in. shall be 30 per cent for grade A, 20 per cent for grade B, and 15 per cent for grade C seamless material.

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine, or by other approved method.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 77.

Hydrostatic Tests

6. Unless otherwise mutually agreed upon between the manufacturer and purchaser, each length of pipe shall be tested at the mill to the hydrostatic pressure specified in the following table, which pressure shall be maintained for not less than five seconds. Seamless pipe 12 in. and over in outside diameter, and all welded pipe shall be struck near both ends while under test pressure by a hammer exerting an energy of not less than 20 ft-lb. at the time of impact.

Schedule Number[a, b]	10	20	30	40	60	80	100	120	140	160
HYDROSTATIC TEST PRESSURE, LB. PER SQ. IN.										
Lap-welded and Grade A Seamless	175	350	500	750	1000	1500	1800	2000	2400	3000
Grades B and C Seamless	200	400	600	800	1200	1600	2000	2400	2800	3200

[a] The schedule numbers indicate approximate values of the expression: $1000 \times \frac{P}{S}$; where P = the internal pressure in pounds per square inch and S = the allowable fiber stress in pounds per square inch.

[b] See Table I for dimensions.

Flattening Tests

7. (*a*) For welded pipe, the crop end cut from each end of each length of pipe shall be flattened between parallel plates with the weld located 90 deg. from the line of direction of the applied force, until opposite walls of the pipe meet. No opening in the weld shall take place until the distance between the plates is less than two thirds of the original outside diameter of the pipe. No cracks or breaks in the metal elsewhere than in the lap-weld shall occur until the distance between the plates is less than one third of the original outside diameter of the pipe. Evidence of laminations or burnt material shall not develop during the entire flattening process. When double-welded pipe is furnished on special order, the flattening test shall show no opening in the weld until the distance between the plates is less than one third of the original outside diameter of the pipe. Precautions shall be taken so that crop ends can be identified with respect to the length from which they are cut.

(*b*) For grade A seamless pipe over 2 in. in nominal diameter, a section of pipe not less than 2½ in. in length shall be flattened between parallel plates until opposite walls of the pipe meet. No cracks or breaks in the metal shall occur until the distance between the plates is less than one third the outside diameter of the pipe, but in no case less than five times the thickness of the pipe wall. Evidence of laminations or burnt material shall not develop during the entire flattening process.

(*c*) For grades B and C seamless pipe over 2 in. in nominal diameter, a section of pipe not less than 2½ in. in length shall be flattened between parallel plates until opposite walls of the pipe meet. No cracks or breaks in the metal shall occur until the distance between the plates is less than one half the outside diameter of the pipe, but in no case less than seven times the thickness of the pipe wall. Evidence of laminations or burnt material shall not develop during the entire flattening process.

Bend Tests

8. For grades A and B seamless pipe 2 in. or under in nominal diameter, a sufficient length of pipe shall stand being bent cold through 90 deg. around a cylindrical mandrel, the diameter of which is twelve times the nominal diameter of the pipe, without developing cracks. When ordered for close coiling (Note 2), the pipe shall stand being bent cold through 180 deg. around a cylindrical mandrel, the diameter of which is eight times the nominal diameter of the pipe, without failure. Grade C seamless pipe need not be subjected to the bend test.

Test Specimens

9. (*a*) Specimens cut longitudinally or in the case of seamless pipe, either longitudinally or transversely, shall be acceptable for the tension test. Tension specimens from welded pipe shall be taken at a point approximately 90 deg. from the weld.

(*b*) Longitudinal tension tests may be made in full section of the pipe up to the capacity of the testing machine. For larger sizes, the tension test specimens shall consist of strips cut from the pipe. The width of these specimens shall be 1½ in. and shall have a gage length of 8 in. for welded pipe and 2 in. for seamless pipe. For seamless pipe, when the pipe wall thickness exceeds ¾ in., the A.S.T.M. standard 0.505-in. round specimen shall be used (Note). Longitudinal tension specimens shall not be flattened between gage marks. The sides of specimens shall be parallel between gage marks.

(*c*) The transverse tension test may be made on seamless pipe 8 in. and over in nominal diameter. Specimens may be taken from a ring cut from the pipe or from sections resulting from the flattening tests. The specimen shall consist of a strip cut transversely from the pipe; the width of the specimen shall be 1½ in. and its gage length 2 in. When the pipe wall thickness exceeds ¾ in., the A.S.T.M. standard 0.505-in. round specimen shall be used (Note). Specimens shall be flattened cold and shall be parallel between gage marks. At the option of the manufacturer, the transverse tension test specimen may be machined off on either surface provided not over 15 per cent of the nominal thickness is removed from either side.

NOTE.—The standard tension test specimens are described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

(*d*) Test specimens for flattening and bend tests shall consist of sections cut from a pipe. Specimens for flattening tests shall be smooth on the ends and free from burrs, except when made on crop ends.

(*e*) All specimens shall be tested at room temperature.

Number of Tests

10. (*a*) *Welded.*—The longitudinal tension test specified in Section 5 shall be made on one pipe from each lot of 400 lengths or fraction thereof, of each size under 6 in., and from each lot of 200 lengths or fraction thereof, of each size 6 in. or over.

Each length of welded pipe shall be subjected to the hydrostatic test specified in Section 6.

The flattening test specified in Section 7 (*a*) shall be made on both crop ends cut from each length of welded pipe.

(*b*) *Seamless.*—One of either of the tests specified in Section 5 shall be made on one pipe from each lot of 400 lengths or fraction thereof, of each size under 6 in. and from each lot of 200 lengths or fraction thereof, of each size 6 in. or over.

Each length of seamless pipe shall be subjected to the hydrostatic test specified in Section 6.

The flattening test specified in Section 7 (*b*) or (*c*) shall be made on one pipe from each lot of 400 lengths or fraction thereof, of each size over 2 in., up to but not including 6 in., and from each lot of 200 lengths or fraction thereof, of each size 6 in. or over.

For grades A and B seamless pipe, 2 in. or under in nominal diameter, the bend test specified in Section 8 shall be made on one pipe from each lot of 400 lengths or fraction thereof of each size.

Retests

11. (*a*) If the results of any chemical or physical tests of any lot do not conform to the requirements specified in Sections 3, 4 (*a*), 5, 7, and 8, retests shall be made on additional pipes of double the original number from the same lot, each of which shall conform to the requirements specified.

(*b*) If the percentage of elongation of any tension test specimen is less than that specified in Section 5 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen, or is outside the middle third of the gage length of the 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed. If a specimen breaks in an inside or outside surface flaw, a retest shall be allowed.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

TABLE I.—DIMENSIONS OF LAP-WELDED AND SEAMLESS STEEL PIPE FOR HIGH-TEMPERATURE SERVICE.[a]

NOTE 1.—Thicknesses shown in **boldface type** in Schedules 30 and 40 are identical with thicknesses for "standard weight" pipe in former lists; those in Schedules 60 and 80 are identical with thicknesses for "extra-strong" pipe in former lists.

NOTE 2.—The decimal thicknesses listed for the respective pipe sizes represent their nominal or average wall dimensions and include an allowance for mill tolerance of 12.5 per cent under the nominal thicknesses.

Nominal Pipe Size, in.	Outside Diameter, in.	Nominal Wall Thickness, in.									
		Schedule Number[b]									
		10	20	30	40	60	80	100	120	140	160
$\frac{1}{8}$	0.405	.....	.....	.....	**0.068**	.....	**0.095**	.....	.....	.....	.....
$\frac{1}{4}$	0.540	.....	.....	.....	**0.088**	.....	**0.119**	.....	.....	.....	.....
$\frac{3}{8}$	0.675	.....	.....	.....	**0.091**	.....	**0.126**	.....	.....	.....	.....
$\frac{1}{2}$	0.840	.....	.....	.....	**0.109**	.....	**0.147**	.....	.....	.....	0.187
$\frac{3}{4}$	1.050	.....	.....	.....	**0.113**	.....	**0.154**	.....	.....	.....	0.218
1	1.315	.....	.....	.....	**0.133**	.....	**0.179**	.....	.....	.....	0.250
$1\frac{1}{4}$	1.660	.....	.....	.....	**0.140**	.....	**0.191**	.....	.....	.....	0.250
$1\frac{1}{2}$	1.900	.....	.....	.....	**0.145**	.....	**0.200**	.....	.....	.....	0.281
2	2.375	.....	.....	.....	**0.154**	.....	**0.218**	.....	.....	.....	0.343
$2\frac{1}{2}$	2.875	.....	.....	.....	**0.203**	.....	**0.276**	.....	.....	.....	0.375
3	3.500	.....	.....	.....	**0.216**	.....	**0.300**	.....	.....	.....	0.437
$3\frac{1}{2}$	4.000	.....	.....	.....	**0.226**	.....	**0.318**	.....	.....	.....	.....
4	4.500	.....	.....	.....	**0.237**	.....	**0.337**	.....	0.437	.....	0.531
5	5.563	.....	.....	.....	**0.258**	.....	**0.375**	.....	0.500	.....	0.625
6	6.625	.....	.....	.....	**0.280**	.....	**0.432**	.....	0.562	.....	0.718
8	8.625	.....	0.250	**0.277**	**0.322**	0.406	**0.500**	0.593	0.718	0.812	0.906
10	10.75	.....	0.250	**0.307**	**0.365**	**0.500**	0.593	0.718	0.843	1.000	1.125
12	12.75	.....	0.250	**0.330**	0.406	0.562	0.687	0.843	1.000	1.125	1.312
14 O. D.	14.0	0.250	0.312	0.375	0.437	0.593	0.750	0.937	1.062	1.250	1.406
16 O. D.	16.0	0.250	0.312	0.375	0.500	0.656	0.843	1.031	1.218	1.437	1.562
18 O. D.	18.0	0.250	0.312	0.437	0.562	0.718	0.937	1.156	1.343	1.562	1.750
20 O. D.	20.0	0.250	0.375	0.500	0.593	0.812	1.031	1.250	1.500	1.750	1.937
24 O. D.	24.0	0.250	0.375	0.562	0.687	0.937	1.218	1.500	1.750	2.062	2.312
30 O. D.	30.0	0.312	0.500	0.625	.....	.....	.....	.....	.....	.....	.....

[a] See Explanatory Note 3.

[b] The schedule numbers indicate approximate values of the expression: $1000 \times \frac{P}{S}$; where P = the internal pressure in pounds per square inch and S = the allowable fiber stress in pounds per square inch.

(*c*) Should a crop end of a finished welded or seamless pipe fail in the flattening test, one retest may be made from the failed end. Pipe may be normalized either before or after the first test, but pipe shall be subjected to only two normalizing treatments.

(*d*) If any specimen shows defective machining or develops flaws not associated with the welding for lap-welded pipe, it may be discarded and another specimen substituted.

WEIGHTS, DIMENSIONS AND PERMISSIBLE VARIATIONS

Weights and Dimensions

12. (*a*) The nominal wall thicknesses for pipe of various diameters are given in Table I.

(*b*) Nipples shall be cut from pipe of the same weight and quality described in these specifications.

Permissible Variations

13. (*a*) *Weight.*—The weight of any length of pipe shall not vary by more than 3.5 per cent under and 6.5 per cent over for pipe of Schedule Nos. 10 to 120, inclusive, nor more than 3.5 per cent under and 10 per cent over for pipe of Schedule Nos. 140 and 160. Unless otherwise mutually agreed upon between the manufacturer and purchaser, pipe in sizes smaller than 4 in. may be weighed in convenient lots, pipe in sizes 4 in. and larger shall be weighed separately.

(*b*) *Diameter.*—Variations in outside diameter shall not exceed those shown in the following table:

NOMINAL PIPE SIZE	PERMISSIBLE VARIATIONS IN OUTSIDE DIAMETER UNDER	OVER
$\frac{1}{8}$ to $1\frac{1}{2}$ in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{1}{64}$ in. (0.015 in.)
2 to 4 in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{1}{32}$ in. (0.031 in.)
5 to 8 in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{1}{16}$ in. (0.062 in.)
10 to 18 in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{3}{32}$ in. (0.093 in.)
20 to 30 in., inclusive	$\frac{1}{32}$ in. (0.031 in.)	$\frac{1}{8}$ in. (0.125 in.)

(*c*) *Thickness.*—The minimum wall thickness at any point for lap-welded and seamless pipe shall not be more than 12.5 per cent under the nominal wall thickness specified.

Lengths

14. Pipe lengths shall be in accordance with the following regular practice:

(*a*) The lengths required shall be specified in the order;

(*b*) No jointers are permitted unless otherwise specified.

WORKMANSHIP AND FINISH

Ends

15. Unless otherwise specified, pipe shall be furnished with plain ends. All burrs at the ends of the pipe shall be removed.

Finish

16. (*a*) The finished pipe shall be reasonably straight and free from injurious defects, and shall have a workmanlike finish.

Depth of Injurious Defect

(*b*) When the depth of defect of either welded or seamless pipe encroaches on the minimum wall thickness (87.5 per cent of the nominal thickness), or is in excess of 12.5 per cent of the nominal wall thickness, such defects shall be considered injurious.

Machining or Grinding Defects

(*c*) Pipe showing moderate slivers may be machined or ground inside or outside to a depth which shall insure the removal of all included scale and slivers, providing the wall thickness is not reduced below the minimum wall thickness required in these specifications. Machining or grinding shall follow inspection of the pipe as rolled, and shall be followed by supplementary visual inspection.

Repair by Welding

(*d*) Repair of injurious defects shall be permitted only subject to the approval of the purchaser. Welding of injurious defects in no case shall be permitted when the depth of defect exceeds $33\frac{1}{3}$ per cent of the nominal pipe wall thickness or the length of repair of seamless pipe exceeds 25 per cent of the nominal diameter of the pipe. Defects shall be thoroughly chipped out before welding. Each length of repaired pipe shall be retested hydrostatically in accordance with Section 6.

Marking

17. Each length of pipe manufactured in accordance with these specifications shall be legibly marked, either by stenciling, stamping or rolling, with the manufacturer's private identifying mark, together with the symbols A 106-A (B or C, or no letter if lap-welded) and an additional S if pipe meets the supplementary requirements specified in Paragraphs S1 to S7. The length and schedule number of the pipe also shall be included. Marking shall be within 12 in. of one end of each length. On pipe sizes 4 in. and larger, the weight shall be given. On small diameter pipe which is bundled, the above information may be legibly stamped on a metal tag securely attached to each bundle. When pipe marked as specified in this section is rejected, the designation A 106 shall be canceled.

INSPECTION AND REJECTION

Inspection

18. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment and at the manufacturer's expense, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

19. Each length of pipe which develops injurious defects in shop working or application shall be rejected, and the manufacturer shall be notified. No rejections, under these or any other specifications, shall be marked as specified in Section 17 for sale under these specifications except where such pipe fails to comply with the weight requirements alone, in which case it may be sold under the weight specifications with which it does comply.

Supplementary Requirements Appear on Pages 646 and 647.

SUPPLEMENTARY REQUIREMENTS FOR SEAMLESS PIPE FOR USE IN CENTRAL STATIONS AT PRESSURES OF 400 LB. PER SQ. IN., OR OVER, AND TEMPERATURES OF 850 F., OR OTHER APPLICATIONS WHERE A SUPERIOR GRADE OF PIPE IS REQUIRED

S1. The requirements in Paragraphs S1 to S7, in addition to those previously specified, apply to seamless pipe 8 in. and over in nominal diameter for use in central stations at pressures of 400 lb. per sq. in. or over and temperatures up to 850 F., or other applications where a superior grade of pipe is required. *These requirements shall not be considered unless specified in the order*, in which event all tests shall be made at the mill at the purchaser's expense and witnessed by his inspector before shipment of the material. If these tests are required for smaller size seamless pipe, they shall be made the subject of agreement between the manufacturer and the purchaser.

Check Analysis

S2. Check analysis may be made on any length of pipe. Individual lengths failing to meet the chemical requirements specified in Section 3 shall be rejected.

Transverse Tension Tests

S3. Transverse tension tests may be made on specimens from both ends of each length of pipe. If the specimen from either end of any length fails to meet the physical properties specified in Sections 5 and 9, that length shall be rejected.

Flattening Tests

S4. The flattening tests specified in Section 7 (*b*) and (*c*) may be made on specimens from both ends of each length of pipe. Crop ends may be used. If the specimen from either end of any length fails to meet the specified requirements, that length shall be rejected.

Finish and Metal Structure

S5. The finished pipe shall be free from all immoderate slivers and depressions. The steel shall have a homogeneous structure as shown by the etching test in Paragraph S6.

Etching Tests

S6. Etching tests[1] may be made on sections from any pipe, and shall show sound and reasonably uniform material, free from injurious laminations, cracks and similar objectionable defects. Sections used for the flattening tests described in Section 7 (*b*) and (*c*) may be used for the etching test. If the specimen from any length shows objectionable defects, that length may be rejected.

---

[1] Pending development of etching methods applicable to the product covered by these specifications, it is recommended that the Tentative Recommended Practice for a Standard Macro-Etch Test for Steel, described in the *National Metals Handbook*, Am. Soc. for Metals, 1933 edition, p. 639, be followed.

Rejection

S7. At the purchaser's discretion, if 10 per cent of the pipe in any one lot fail to meet the requirements of Paragraphs S2 to S6, the entire lot may be rejected. Rejection of a lot shall be based on tests from not less than two pipes. A lot shall consist of all the pipe of the same size and wall thickness from any one heat bought by a purchaser.

EXPLANATORY NOTES

NOTE 1.—This contemplates temperatures up to 850 F. for power piping and 1000 F. for oil piping. Higher temperatures may be used at the discretion of the designing engineer, provided suitable reduction in the allowable working stress is made. For allowable working stresses, see the Proposed Code for Pressure Piping, Project B31 of the American Standards Association, and the Boiler Construction Code of the American Society of Mechanical Engineers.

NOTE 2.—Grade A rather than Grades B or C seamless pipe should be used for close coiling, cold bending or for forge welding. The purpose for which pipe is to be used should be stated on the face of the order.

NOTE 3.—Table I is the recommendation of the Sectional Committee on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing, functioning under the procedure of the American Standards Association, A.S.A. Project No.: B36.

TENTATIVE SPECIFICATIONS

FOR

WROUGHT-IRON PLATES[1]

A.S.T.M. Designation: A 42 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover wrought-iron[2] plates for general fabrication purposes, including bending and flanging, in thicknesses $\frac{3}{16}$ in. and over.

Manufacture

2. (*a*) All plates shall be rolled from blooms, piles or slabs which are entirely free from any admixture of iron scrap (Note) or steel.

(*b*) Piles for plates shall be made from wrought iron.[2] The constituent bars shall be the full length of the pile.

NOTE.—The term iron scrap applies only to foreign or bought scrap and does not include local mill products which are free from foreign or bought scrap. Any local mill products used shall be the equal or of a higher grade than the material specified.

Chemical Composition

3. The iron shall conform to the following requirement as to chemical composition:

Manganese, max., per cent 0.05

Tension Tests

4. (*a*) The plates shall conform to minimum requirements as to tensile properties, calculated from the following formulas:

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-2 on Wrought Iron.

These tentative specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Wrought-Iron Plates (A.S.T.M. Designation: A 42 - 30), 1933 Book of A.S.T.M. Standards, Part I, p. 459.

[2] Wrought iron is defined as follows in the Standard Definitions of Terms Relating to Wrought Iron Specifications (A.S.T.M. Designation: A 81) of the American Society for Testing Materials:

Wrought Iron.—A ferrous material, aggregated from a solidifying mass of pasty particles of highly refined metallic iron with which, without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag.

Tensile strength, lb. per sq. in. = 51,000 − (1500 × transverse ductility of plate (expressed as percentage elongation in 8 in.))

Longitudinal elongation in 8 in., per cent = 16 − transverse ductility (expressed as percentage elongation in 8 in.)

Yield point, lb. per sq. in 27,000

(*b*) On the basis of the above formulas, the purchaser of the plate shall indicate the transverse ductility desired in conformity with his fabrication requirements. The usual longitudinal strength and ductility are directly related thereto, and are scaled downward in ratio to the increase in transverse properties desired.

(*c*) Representative requirements in accordance with the formulas are as follows:

TRANSVERSE DUCTILITY (ELONGATION IN 8 IN.), PER CENT		MINIMUM LONGITUDINAL PROPERTIES		
		TENSILE STRENGTH, MIN., LB. PER SQ. IN.		ELONGATION IN 8 IN., MIN., PER CENT
2	51,000 − (1500 × 2) =	48 000[a]	(16 − 2) =	14[a]
3		46 500		13
4		45 000		12
5		43 500		11
6		42 000		10
7		40 500		9
8		39 000		8

---

[a] Test requirements for the usual full longitudinal rolling of the plate.

(*d*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine. The speed of the crosshead of the machine shall not exceed $\frac{3}{4}$ in. per minute.

Modifications in Elongation

5. (*a*) For plates under $\frac{7}{16}$ in. in thickness, a deduction of 1 per cent from the percentages of elongation specified in Section 4 shall be made for each decrease of $\frac{1}{16}$ in. in thickness below $\frac{7}{16}$ in.

(*b*) For plates over $\frac{3}{4}$ in. in thickness, a reduction of 1000 lb. per sq. in. from the indicated tensile strength will be allowed for each increase of $\frac{1}{8}$ in. in thickness over $\frac{3}{4}$ in., with a proportional reduction for fractional parts of $\frac{1}{8}$ in.; but in no case less than 39,000 lb. per sq. in.

Bend Tests

6. (*a*) *Cold-bend Tests.*—The test specimen shall stand being bent cold through 90 deg., without fracture on the outside of the bent portion, around a pin the diameter of which is:

$$d = \frac{40 \times \text{thickness of plate}}{\text{specified longitudinal elongation in 8 in., per cent}}$$

(*b*) *Nick-bend Tests.*—The test specimen, when nicked on one side and slowly broken, shall show a wholly fibrous fracture.

Test Specimens

7. (*a*) Tension and bend test specimens shall be taken from the finished plate and except as specified in Paragraph (*b*) shall be of the full thickness of the plate as rolled.

(*b*) Test specimens may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel. When plates are 1½ in. or over in thickness, the specimens may be machined to a thickness of not less than ¾ in. or, if desired, to a diameter of not less than ¾ in. for a distance of not less than 9 in.

(*c*) The machined edges of rectangular bend test specimens may be rounded to a radius of not over $\frac{1}{16}$ in.

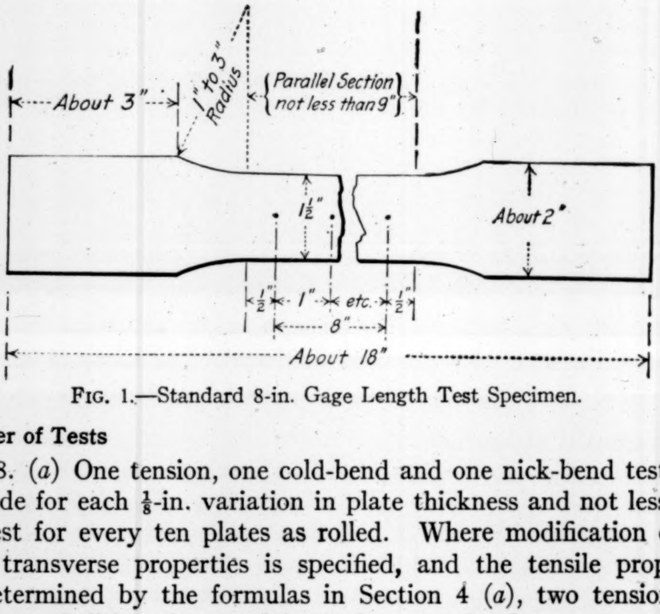


FIG. 1.—Standard 8-in. Gage Length Test Specimen.

Number of Tests

8. (*a*) One tension, one cold-bend and one nick-bend test shall be made for each ⅛-in. variation in plate thickness and not less than one test for every ten plates as rolled. Where modification of the usual transverse properties is specified, and the tensile properties are determined by the formulas in Section 4 (*a*), two tension test specimens shall be taken at right angles to each other, one parallel to the longitudinal axis and the other parallel to the transverse axis.

(*b*) If any test specimen fails to conform to the requirements specified by reason of an apparent local defect, a retest shall be allowed. If the retest also fails, the plates represented by such test will be rejected.

Other Tests

9. Where desired, the purchaser may, at his own expense, subject the material to chemical, microscopic, or other tests to determine its quality in conformity with the intent of these specifications.

TABLE I.—PERMISSIBLE VARIATIONS OF RECTANGULAR PLATES ORDERED TO WEIGHT.

Ordered Weight, lb. per sq. ft.	Permissible Variations in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Ordered Weights																		Ordered Weight, lb. per sq. ft.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over		
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
Under 5	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...	Under 5
5 to 7.5 excl.	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...	5 to 7.5 excl.
7.5 " 10 "	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 " 10 "
10 " 12.5 "	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 " 12.5 "
12.5 " 15 "	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 " 15 "
15 " 17.5 "	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 " 17.5 "
17.5 " 20 "	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 " 20 "
20 " 25 "	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 " 25 "
25 " 30 "	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 " 30 "
30 " 40 "	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 " 40 "
40 or over	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 or over

NOTE.—The weight per square foot of individual plates shall not vary from the ordered weight by more than one and one-third the amount given in this table.

TABLE II.—PERMISSIBLE OVERWEIGHTS OF RECTANGULAR PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in. excl.	120 to 132 in excl.	132 in. or over	
Under $\frac{1}{8}$	9	10	12	14	....	....	..	..	..	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$ excl.	8	9	10	12	....	....	..	..	..	$\frac{1}{8}$ to $\frac{3}{16}$ excl.
$\frac{3}{16}$ " $\frac{1}{4}$ "	7	8	9	10	12	....	..	..	..	$\frac{3}{16}$ " $\frac{1}{4}$ "
$\frac{1}{4}$ " $\frac{5}{16}$ "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ " $\frac{5}{16}$ "
$\frac{5}{16}$ " $\frac{3}{8}$ "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ " $\frac{3}{8}$ "
$\frac{3}{8}$ " $\frac{7}{16}$ "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ " $\frac{7}{16}$ "
$\frac{7}{16}$ " $\frac{1}{2}$ "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ " $\frac{1}{2}$ "
$\frac{1}{2}$ " $\frac{5}{8}$ "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ " $\frac{5}{8}$ "
$\frac{5}{8}$ " $\frac{3}{4}$ "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ " $\frac{3}{4}$ "
$\frac{3}{4}$ " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ " 1 "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

NOTE.—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third the amount given in this table.

Variations in Weight and Thickness

10. The weight or thickness of plates shall be covered by the following permissible variations. One cubic inch of wrought iron is assumed to weigh 0.2776 lb.

(*a*) *Plates, When Ordered to Weight per Square Foot.*—The weight of each lot[1] of plates in each shipment shall not vary from the weight ordered more than the amounts given in Table I.

(*b*) *Plates, When Ordered to Thickness.*—The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight in each lot[1] of plates in each shipment shall not exceed the amounts given in Table II.

Finish

11. The plates shall be straight, smooth and free from cinder spots and holes, injurious flaws, buckles, blisters, seams and laminations.

Marking

12. The plates shall be stamped or otherwise marked as designated by the purchaser.

Inspection

13. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the plates ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the plates are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The purchaser may make the tests to govern the acceptance or rejection of plates at his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection

14. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 13 (*b*) shall be reported within five working days from the receipt of samples.

---

[1] The term "lot" as applied to Table I means all the plates of each group width and group weight. As applied to Table II, it means all the plates of each group width and group thickness.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing

15. Samples tested in accordance with Section 13 (*b*), which represent rejected plates, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
CAST-IRON CULVERT PIPE[1]

A.S.T.M. Designation: A 142 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1932; REVISED, 1934.

Scope. 1. These specifications cover cast-iron pipe intended for use in the construction of culverts.

Classes. 2. These specifications cover three classes of pipe: namely, Standard Cast-Iron Culvert Pipe; Heavy Cast-Iron Culvert Pipe, and Extra-Heavy Cast-Iron Culvert Pipe.

Type of Pipe. 3. (*a*) Each length of pipe shall be cast as a unit and shall have a full circular cross-section with outside and inside circumferences concentric. Unless otherwise specified, the pipe may be smooth, corrugated or ribbed.

(*b*) The pipe shall be provided with suitable devices, such as hub ends or interlocking ends, to prevent displacement at joints.

MANUFACTURE

Material. 4. The pipe shall be manufactured of cast iron of good quality and of such character as shall make the metal of the castings strong, tough and of even grain, and soft enough to admit satisfactorily of drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola, air-furnace, or electric furnace.

Casting. 5. Pipe may be cast either vertically or horizontally in dry or green-sand molds or by centrifugal processes.

Coating. 6. (*a*) All pipe shall be completely coated inside and out by immersion in coal-tar pitch varnish to which sufficient oil shall have been added to make a smooth coating, tough and tenacious when cold, and not tacky nor brittle nor with any tendency to scale off.

(*b*) Prior to dipping, the pipe shall be thoroughly cleaned of rust, loose scale, grease and dirt.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee A-3 on Cast Iron.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

7. (*a*) The iron shall conform to the following ladle analysis requirements as to chemical composition:

Phosphorus, maximum, per cent	0.90
Sulfur, maximum, per cent	0.12

(*b*) The manufacturer shall maintain a daily record of chemical analyses, and the portions of this record which concern pipe ordered by a purchaser shall be open to the inspection of the purchaser at all times.

PHYSICAL PROPERTIES AND TESTS

Strength Requirements.

8. (*a*) The pipe shall not fail and shall develop no cracks when tested under the following loads by the three-edge-bearing method:

CLASS OF PIPE	LOAD, LB. PER FOOT, OF LAYING LENGTH
Standard pipe	2000*D*
Heavy pipe	3000*D*
Extra-heavy pipe	4000*D*

NOTE.—*D* = nominal inside diameter of pipe in feet.

(*b*) Pipe specimens tested for strength shall not be tested to destruction if they will sustain, without cracking, a load 10 per cent in excess of the specified load. If the purchaser desires tests to destruction he shall specify on the order the number of such tests which will be required.

Three-Edge-Bearing Method.

9. (*a*) *Smooth Pipe.*—The lower bearing for the pipe shall consist of two wooden strips with vertical sides having their interior top corners rounded to a radius of approximately ½ in. The strips shall be straight and shall be securely fastened to a rigid block with the interior vertical faces spaced at a distance apart not less than ½ in. nor more than 1 in. for each foot of nominal pipe diameter, with a minimum spacing of 1 in. for any size of pipe. The upper bearing shall be a rigid wooden block, straight and true from end to end. The upper and lower bearings shall extend the full length of the outside of the barrel of the pipe exclusive of the bell, if any. The pipe shall be placed symmetrically between the two bearings and the center of the application of load shall be at the center of the length of pipe, as illustrated in Figs. 1 and 2. In testing pipe which is "out of line" the lines of the bearings chosen shall be from those which appear to give the most favorable conditions for fair test. In testing pipe, the

specimen shall be placed so that the upper bearing will be along the thinnest element.

(*b*) *Corrugated or Ribbed Pipe.*—For corrugated or ribbed pipe the requirements for the three-edge-bearing method shall be the same as described in Paragraph (*a*) for smooth pipe. In the case of corrugated pipe, the bearing blocks shall be placed in contact with the outside crests of the corrugations. In the case of ribbed pipe, the bearing blocks shall be placed in contact with the tops of the transverse ribs. If the ribbed pipe has longitudinal ribs, the pipe shall be placed so that the bearing blocks will be, as nearly as possible, midway between the longitudinal ribs.

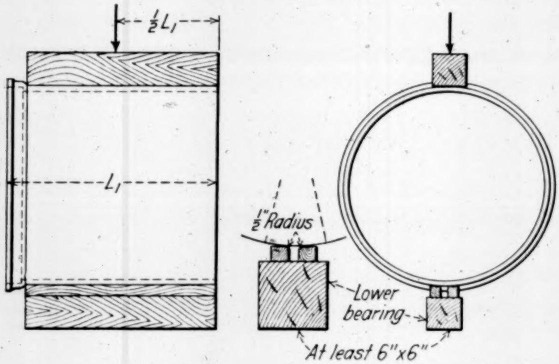


FIG. 1.—Three-Edge Bearings for Pipe with Bell End.

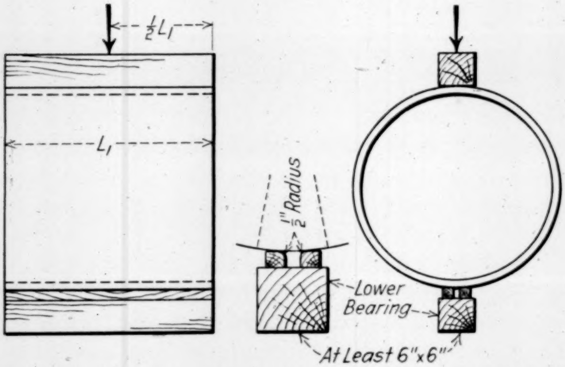


FIG. 2.—Three-Edge Bearings for Pipe Without Bell End.

Testing Apparatus. 10. Any mechanically driven or hand-power device, which meets the following requirements, may be used:

(*a*) It shall be substantially built and rigid throughout so that the distribution of the load to the specimen will not be affected appreciably by the deformation or yielding of any part.

(*b*) It shall provide for an approximately continuous application of load by means of a head which, during the test, moves at an approximately uniform rate not to exceed:

0.05 in. per minute for pipe less than 24 in. in diameter
0.10 in. per minute for pipe 24 to 36 in. in diameter
0.20 in. per minute for pipe more than 36 in. in diameter

(*c*) It shall provide means for the determination of load with an error not greater than 2 per cent.

Number of Tests.

11. The purchaser may require strength tests in such numbers as he may deem necessary, provided that if the pipe meets the requirements as to shell thickness and weight, the number of specimens tested shall not exceed three pipe or 5 per cent, whichever may be larger, of each size and class ordered. In placing an order the purchaser shall specify the number of strength tests which will be required.

Selection of Test Specimens.

12. All pipe for purpose of tests shall be selected at random by the purchaser from the stock of the manufacturer, or from the pipe as delivered to the work, and shall be pipe which would not otherwise be rejected under these specifications.

Length of Test Specimens.

13. The laying length of test specimens of pipe shall be not less than 3 nor more than 4 ft. If the manufacturer proposes to furnish, for use in the work, pipe having a length greater than 4 ft., he shall furnish for the required tests a sufficient number of test specimens of the required length.

Testing and Disposal of Test Specimens.

14. Pipe specimens shall be tested under a load 10 per cent in excess of the load specified for the particular class of pipe. Shipments represented by specimens which sustain the specified load without the development of cracks shall be accepted as fulfilling the strength requirements. Specimens of pipe which meet all other requirements of the specifications and which sustain a load 10 per cent in excess of that specified without the development of cracks shall be accepted for use. The cost of specimens which fail to sustain the specified load, or a load 10 per cent in excess of that specified, shall be borne by the manufacturer.

NOTE.—It is recommended that a test specimen which has been accepted for use be marked with a suitable identification symbol and be installed in the culvert structure in such location as will subject it to the least severe loading.

Retests.

15. Pipe shall be acceptable under the strength tests when all test specimens fulfill the strength test requirements. Should any pipe fail to meet the test requirements, then the manufacturer will

be allowed a retest on two similar specimens for each specimen that failed, and the pipe shall be acceptable only when all of these retest specimens fulfill the test requirements. No further retests shall be permitted.

SIZES, WEIGHTS AND PERMISSIBLE VARIATIONS

Diameter. 16. (*a*) The minimum nominal diameter of pipe shall be 12 in.

(*b*) The minimum inside diameter of any pipe shall be not less than the nominal diameter by more than $\frac{1}{8}$ in.

TABLE I.—DIMENSIONS AND WEIGHTS OF SMOOTH CAST-IRON CULVERT PIPE.

Nominal Diameter, in.	Standard Pipe (2000*D*)		Heavy Pipe (3000*D*)		Extra-Heavy Pipe (4000*D*)	
	Nominal Thickness, in.	Nominal Weight per Foot of Barrel, lb.[a]	Nominal Thickness, in	Nominal Weight per Foot of Barrel, lb.[a]	Nominal Thickness, in.	Nominal Weight per Foot of Barrel, lb.[a]
12	0.37	45	0.37	45	0.40	49
14	0.37	52	0.40	57	0.46	65
16	0.40	64	0.46	74	0.53	86
18	0.42	76	0.52	95	0.60	110
20	0.47	94	0.57	115	0.66	134
24	0.56	135	0.69	167	0.80	195
30	0.70	211	0.86	261	1.00	304
36	0.84	304	1.03	374	1.20	438
42	0.98	414	1.20	509	1.40	597
48	1.12	540	1.38	669	1.60	779

[a] All weight values are per foot of barrel exclusive of hub.

TABLE II.—DIMENSIONS AND WEIGHTS OF CORRUGATED CAST-IRON CULVERT PIPE AND RIBBED CAST-IRON CULVERT PIPE.

	STANDARD PIPE (2000*D*)	
NOMINAL DIAMETER, IN.	NOMINAL THICKNESS, IN.	NOMINAL WEIGHT PER FOOT OF BARREL, LB.
15	0.25	45
18	0.25	50
24	0.31	85
30	0.38	125
36	0.44	165

Length. 17. Unless otherwise specified, pipe shall have a minimum laying length of 3 ft.

Dimensions and Weight. 18. (*a*) The shell thickness and the weights per linear foot for pipe of the various classes shall conform to the requirements given in Tables I and II.

(*b*) The shell thickness at any point shall be not more than 15 per cent under the thickness specified in Tables I and II.

(*c*) The weight of any section of pipe shall be not more than 5 per cent under the weight specified in Tables I and II.

Waiver of Strength Tests. 19. After the strength, shell thickness and weight of pipe of a particular class and size furnished by the manufacturer has been established by tests, the purchaser may elect to waive further strength tests and to accept pipe of that particular class, size and manufacture on the basis of the shell thickness and weight thus established, subject to the tolerances specified in Section 18 (*b*) and (*c*). Under these conditions the acceptability of the larger sizes of pipe shall not be based on the results of strength tests on smaller sizes.

WORKMANSHIP AND FINISH

Character of Castings. 20. (*a*) Pipe shall be practically straight and of true circular cross-section. They shall be sound, smooth and free from cracks, scales, lumps, blisters, sand holes, "cold shuts," or other defects which would render them unfit for the use intended.

(*b*) All pipe shall be carefully examined for defects and sounded with a hammer before shipment. No fillings with metal, cement or other material, or so-called "burning on" of iron will be permitted.

WEIGHING AND MARKING

Weighing. 21. If required by the purchaser, each pipe shall be weighed and, after coating, the weight plainly marked thereon with white paint.

Marking. 22. The brand of the manufacturer shall be legibly stamped-in or cast or stencilled on the metal of each pipe.

INSPECTION AND REJECTION

Inspection. 23. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities including labor to satisfy him that the pipe are being furnished in accordance with these specifications. All tests and inspections shall, if possible, be made at the place of manufacture prior to shipment and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The purchaser reserves the right, if deemed necessary, to inspect and test the pipe after delivery on the work.

Rejection. 24. (*a*) All pipes which fail to conform to any of the provisions of these specifications shall be subject to rejection.

(*b*) Pipes which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified promptly.

TENTATIVE METHOD FOR SAMPLING MOLYBDENUM SALTS AND COMPOUNDS FOR METALLURGICAL USE[1]

A.S.T.M. Designation: A 156 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

1. For convenience to the user molybdenum salts and compounds for metallurgical use are generally shipped in small bags, each holding 5 lb. of contained molybdenum.

Sampling Small Bags

2. When received in the standardized small packages, these products shall be sampled by selecting at random one-twentieth of the bags that may bear the same manufacturing lot number, and the combined content of these bags shall be reduced and analyzed as a separate sample. When a shipment cannot be divided by lot numbers, one-twentieth of the total number of bags constituting the shipment shall be selected and treated as one sample. The material forming a sample shall be crushed if necessary, and in any event passed through a No. 10 sieve. The sample after sieving shall be thoroughly mixed by coning and then reduced to about 2 lb. by quartering or by means of a riffle sampler. The reduced sample shall then be crushed in rolls, if necessary, and passed through a No. 60 sieve. The sample after sieving shall again be mixed by coning and then divided through a riffle, preferably a Jones divider, into the required number of analytical samples. Each analytical sample shall be tightly bottled immediately.

Sampling Barrels or Large Bags

3. If received in barrels or large bags, these products shall be sampled by selecting about one-twentieth of the content of each package that may bear the same manufacturing lot number, and the combined material selected shall be reduced and analyzed as a separate sample. When a shipment cannot be divided by lot numbers, about one-twentieth of the content of each package in the shipment shall be selected, and the combined material selected shall be treated as one sample. The material comprising a sample shall be thoroughly

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee A-9 on Ferro-Alloys.

mixed by coning and reduced by half-shovelling, alternating the operations until the residual weight reaches about 40 lb. Segregation of sizes shall be carefully avoided. The sample thus reduced shall be crushed if necessary to pass through a No. 10 sieve, and the subsequent sampling procedure shall be as prescribed in Section 2.

Correcting Sample to Dry Net Weight

4. Absorption of moisture by the material would depress the analytical percentage with respect to the dry basis, on which the product was analyzed when packed. Accordingly, any analytical sample shall be dried at 110 C. before analysis, and the sampler's moist net weight of the shipment, of a manufacturing lot, or of any constituent package shall be appropriately corrected to the corresponding dry net weight, thus leading to the proper weight of contained molybdenum.

TENTATIVE SPECIFICATIONS
FOR
PIG LEAD[1]

A.S.T.M. Designation: B 29 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1919; ADOPTED IN AMENDED FORM, 1923; REISSUED AS TENTATIVE, 1934.[2]

Scope

1. These specifications cover lead in pig form, made from ore or other material, by processes of reduction and refining, and not reclaimed lead. Lead complying with these specifications is intended to be refined lead, produced by lead producers who use well recognized and accepted processes for smelting and fully refining their products. Reclaimed lead which is prohibited by these specifications is a commercial product obtained by the recovery of metallic lead and its alloys, by the simple reclaiming process of melting, drossing and casting.

Grades

2. Under these specifications pig lead is considered in three grades, as follows:

Grade I. Corroding Lead
Grade II. Chemical Lead
Grade III. Common Lead

Quality

3. The maker shall use care to have each carload of as uniform quality as possible.

Corroding Lead (Grade I)

4. Corroding Lead (Grade I) shall conform to the following requirements as to chemical composition:

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-2 on Non-Ferrous Metals and Alloys.

These specifications are in effect a revision of, and replace the former Standard Specifications for Pig Lead (A.S.T.M. Designation: B 29 - 23), which standard was accordingly discontinued in 1934.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

Silver, max., per cent	0.0015
Copper, max., per cent	0.0015
Copper and silver together, max., per cent	0.0025
Arsenic, max., per cent	0.0015
Antimony and tin together, max., per cent	0.0095
Zinc, max., per cent	0.0015
Iron, max., per cent	0.002
Bismuth, max., per cent	0.05
Lead (by difference), min., per cent	99.94

NOTE.—The maximum limits for bismuth, copper and silver have been given, but it is not expected that any delivery will contain the maximum of all three.

Chemical Lead (Grade II)

5. Chemical Lead (Grade II) is a designation that has been used for many years in the trade to describe the undesilvered lead produced from Southeastern Missouri ores. Chemical lead shall conform to the following requirements as to chemical composition:

Silver, per cent	0.020, max. 0.002, min.
Copper, per cent	0.080, max. 0.040, min.
Antimony, arsenic and tin together, max., per cent	0.002
Zinc, max., per cent	0.001
Iron, max., per cent	0.0015
Bismuth, max., per cent	0.005
Lead (by difference), min., per cent	99.90

Common Lead (Grade III)

6. Common Lead (Grade III) shall conform to the following requirements as to chemical composition:

Silver, max., per cent	0.002
Copper, max., per cent	0.0025
Arsenic, antimony and tin together, max., per cent	0.015
Bismuth, max., per cent	0.15
Iron, max., per cent	0.002
Zinc, max., per cent	0.002
Lead (by difference), min., per cent	99.85

NOTE.—Common Lead (Grade IIIa) conforms to the above analysis except that bismuth shall not be over 0.25 per cent and the total purity shall not be less than 99.73 per cent lead.

Sampling

7. (*a*) In sampling, a carload or less shall be considered a lot or unit. One pig shall be taken to represent each ton of lead in the lot. The pigs thus selected shall be sampled by one of the following methods:

(*1*) By sawing completely through, as illustrated in Fig. 1;

(*2*) By punching completely through (if equipment permits) or punching half-way through from two opposite sides, as illustrated in Figs. 2 and 3;

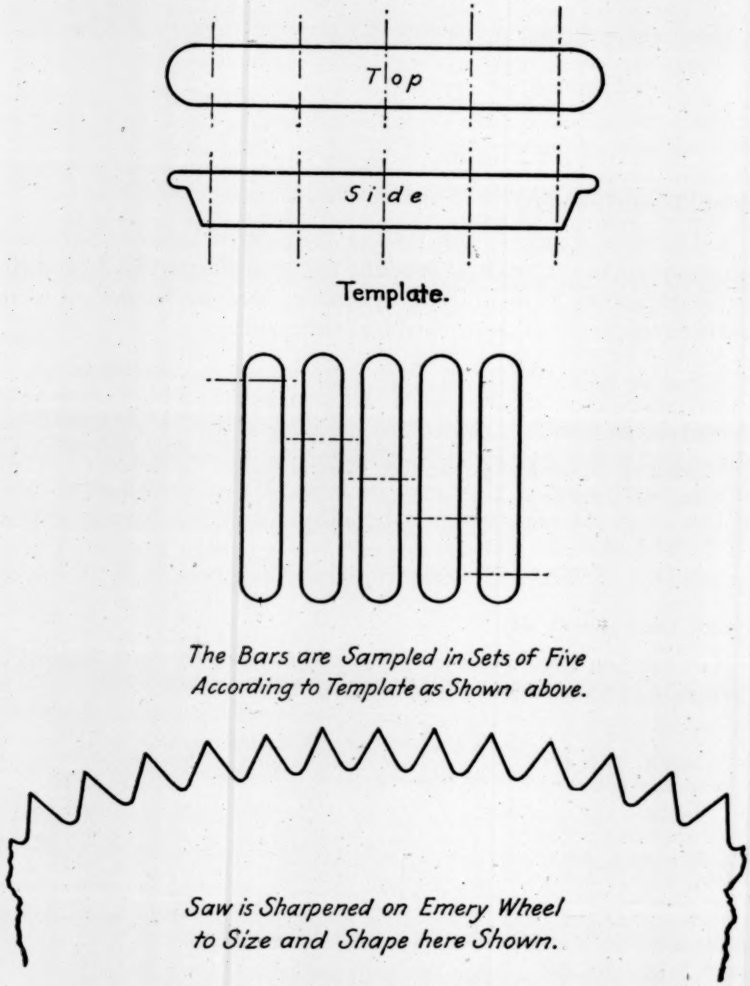

Top
Side
Template.
The Bars are Sampled in Sets of Five
According to Template as Shown above.
Saw is Sharpened on Emery Wheel
to Size and Shape here Shown.

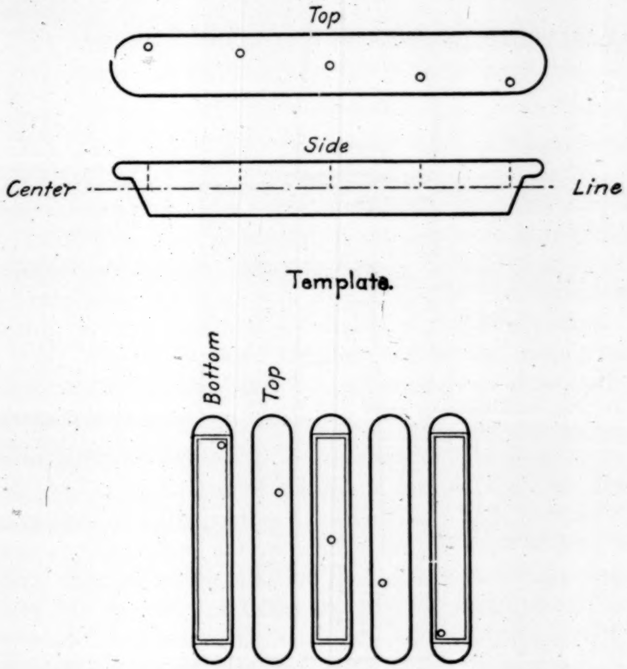
FIG. 1.—Saw Method of Sampling Lead.

(*3*) By drilling at least half-way through.

(*b*) Whenever the surface of the pigs to be sampled is dirty, care shall be taken to see that none of the dirt or foreign material gets into the sample.

Sawing

8. If the sample is taken by sawing, the sawings from all the pigs shall be thoroughly mixed and quartered and the sample for analysis drawn from the mixed material. Care shall be taken that the sawings are free from all extraneous material.



The Bars Selected as Samples are Placed in a Line with every other Bar, Bottom Side up. The Sampling is Done according to Template in Sets of five Bars each, as Indicated above. The Punch must be Driven Halfway through the Bar. In Case a Larger Sample is Desired, the Bars are Turned over and Sampled on the other Diagonal.

FIG. 2.—Punch Method of Sampling Lead.

Punching or Drilling

9. If the sample is taken by punching or drilling, the holes shall be spaced along a diagonal line from one corner of the pig to the other. Sampling in this manner may be so arranged that one or more holes are made in each of several pigs of a group in such positions that they represent consecutive positions on the diagonal of a single pig. (See illustration in Fig. 2.)

(*a*) If punchings are taken, they may be carefully melted in a clean graphite crucible, and either granulated by carefully pouring into distilled water and thoroughly drying, or casting into thin slabs which shall be sawed completely through in several places and the sawings treated as described in Section 8.

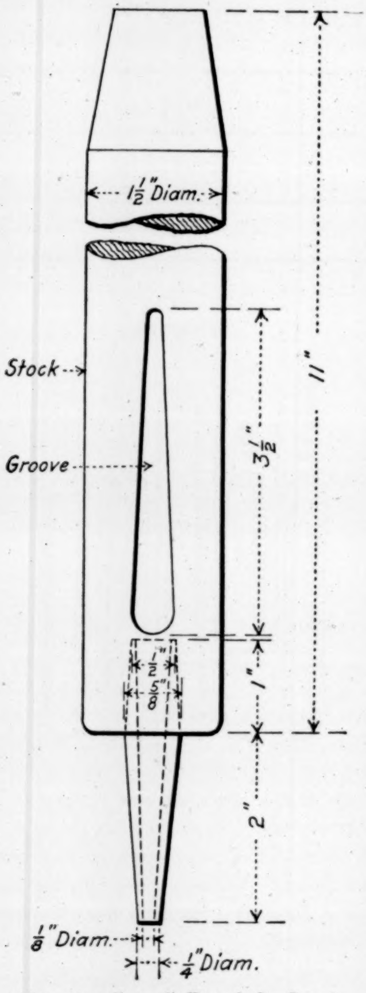


FIG. 3.—Sample Punch for Lead.

(*b*) If drillings are taken, they may be clipped and mixed, and the sample for analysis drawn from the mixed material; or they may be melted as in the case of punchings.

Methods of Chemical Analysis

10. The chemical analysis shall be made in accordance with the Standard Methods of Chemical Analysis of Pig Lead (A.S.T.M. Designation: B 35) of the American Society for Testing Materials.[1]

Marking

11. A brand shall be cast or otherwise plainly marked upon each pig by which the maker and grade may be identified.

Claims

12. (*a*) Claims to be considered shall be made in writing within thirty days of receipt of the material at the purchaser's plant and the results of the purchaser's tests shall be given. The seller shall be given one week from date of receipt of such claim to investigate his records, and then shall agree either to satisfy the claim or to the submission of samples to an umpire. No claim shall be considered unless the sample pigs can be shown to the seller's representative.

(*b*) Where the lead satisfies the purity requirements of these specifications, it shall not be condemned for defects in the products in which it is used.

Investigation of Claims

13. On questions of purity, a sample shall be drawn by representatives of both parties in accordance with Section 7 on sampling. The properly mixed and quartered sample shall be separated into three parts, each of which shall be placed in a sealed package, one for the seller, one for the purchaser and one for an umpire, if necessary. The seller and purchaser shall each make an analysis, and if the results do not establish or dismiss the claim to the satisfaction of both parties, the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of quality, and whose determination shall be final.

Settlement of Claims

14. The expenses of the seller's representative and of the umpire shall be paid by the loser or divided in proportion to concession made in case of compromise. In case of rejection being established, damages shall be limited to the payment of freight both ways by the seller for substitution of an equivalent weight of lead meeting these specifications.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 791.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM SHEET AND PLATE[1]

A.S.T.M. Designation: B 25 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1918; ADOPTED IN AMENDED FORM, 1929;
REISSUED AS TENTATIVE, 1933; REVISED, 1934.

Scope

1. These specifications cover aluminum sheet and plate. Commercial flat sheet shall be supplied on orders for sheet, except where coiled or strip sheet is specifically ordered.

Manufacture

2. No scrap shall be used in the manufacture of aluminum sheet and plate except such as shall accumulate at the manufacturer's plants from material of similar composition and of his own manufacture.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition

3. The sheet and plate shall contain a minimum of 99 per cent aluminum as determined by chemical analysis.

Samples

4. Samples for analysis shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser. Samples for analysis may be obtained from the tension or bend test specimens described in Section 7. The sample for analysis may be prepared by shearing or by drilling or machining without the use of any lubricant in such a manner as to give a sample representative of the entire cross-section of the sheet or plate. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser and one for an umpire if necessary.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

These specifications are in effect a revision of and replace the former Standard Specifications for Aluminum Sheet (A.S.T.M. Designation: B 25 – 29) which were accordingly discontinued in 1933

PHYSICAL PROPERTIES AND TESTS

Tensile Requirements

5. (*a*) Sheet shall be supplied in the temper specified in the contract or purchase order and shall conform to the following minimum requirements as to tensile properties for the specified temper and thickness:

TEMPER	THICKNESS, IN.	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 2 IN., MINIMUM, PER CENT
Soft	0.013 to 0.019	15 500 max.	15
	0.020 to 0.031	15 500 max.	20
	0.032 to 0.050	15 500 max.	25
	0.051 to 0.250	15 500 max.	30
Half Hard	0.013 to 0.019	16 000 min.	3[a]
	0.020 to 0.031	16 000 min.	4[a]
	0.032 to 0.050	16 000 min.	5[a]
	0.051 to 0.113	16 000 min.	7[a]
	0.114 to 0.250	16 000 min.	7
Three-quarter Hard	0.013 to 0.019	19 000 min.	1
	0.020 to 0.031	19 000 min.	2
	0.032 to 0.050	19 000 min.	3
	0.051 to 0.162	19 000 min.	4
Hard	0.013 to 0.019	22 000 min.	1
	0.020 to 0.031	22 000 min.	2
	0.032 to 0.050	22 000 min.	3
	0.051 to 0.128	22 000 min.	4

---

[a] This value is required for flat sheet. For coiled sheet in the half-hard temper, the elongation may be less than that for flat sheet by 1 per cent in 2 in. The maximum thickness of coiled or strip sheet commercially available in the half-hard temper is 0.080 in.

(*b*) Unless otherwise specified, plate (thicknesses 0.250 in. and over) shall be supplied as rolled (see Explanatory Note 2) and tension tests shall not be required.

(*c*) If so specified, plate shall be supplied in the soft temper in thicknesses from 0.250 to 3.000 in., in which case the tensile strength shall not exceed 19,000 lb. per sq. in. and the elongation shall not be less than 25 per cent in 2 in.

Bend Tests

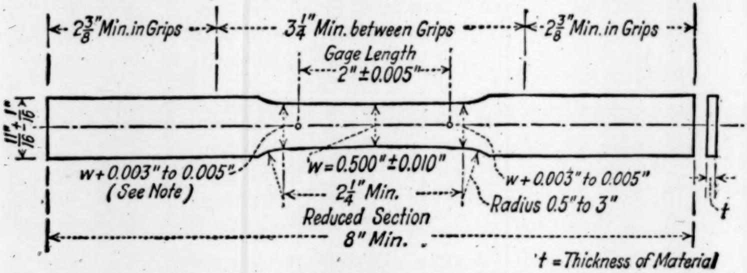
6. (*a*) Bend test specimens taken from sheet in the soft or in the half-hard temper or from plate in the soft temper or as rolled shall stand being bent cold through 180 deg. flat on themselves without cracking.

(*b*) Bend test specimens taken from sheet in the three-quarter-hard temper shall stand being bent cold through 180 deg. around a pin having a diameter equal to four times the thickness of the sheet without cracking.

(*c*) The bend test shall not be required for sheet in the hard temper.

Test Specimens

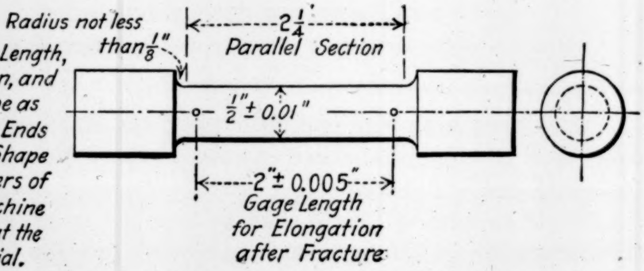
7. (*a*) *Tension Tests.*—Tension test specimens for sheet in the half-hard temper shall be taken parallel to the direction of rolling; for sheet in the soft, three-quarter-hard and hard tempers, the tension test specimens may be taken in any direction. (See Explanatory Notes 1 and 3.) For sheet and plate under 0.500 in. in thickness the standard sheet tension test specimen shown in Fig. 1 shall be used. For plate 0.500 in. or over in thickness, the standard 0.505-in. diameter round specimen shown in Fig. 2 or a similar round specimen having the maximum possible dimensions proportional to those of the standard 0.505-in. diameter specimen shall be used.


2⅜" Min. in Grips
3¼" Min. between Grips
2⅜" Min. in Grips
Gage Length
2" ± 0.005"
11/16" ± 1/16"
w + 0.003" to 0.005" (See Note)
w = 0.500" ± 0.010"
w + 0.003" to 0.005"
2¼" Min.
Reduced Section
Radius 0.5" to 3"
8" Min.
t
t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 1.—Standard Tension Test Specimen for Sheet Metals.


Radius not less than 1/8"
2¼
Parallel Section
1/2" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) *Bend Tests.*—Bend test specimens may be taken in any direction from sheet in the soft, half-hard or three-quarter-hard temper and from plate in the soft temper or as rolled. Bend test specimens from thin sheet and strip shall be of the full thickness, and in the case of strips 1 in. in width or under, of the full width of the material. The width of specimens from material over 1 in. in width shall be six times the thickness, but not less than 1 in. The edges may be rounded to a $\frac{1}{16}$-in. radius. When practicable the length shall be at least 6 in. For plates over 0.500 in. in thickness a machined bend test specimen 1 by ½ in. in cross-section and at least 6 in. in length shall be used. The edges may be rounded to a $\frac{1}{16}$-in. radius. When permitted by the inspector, the cross-section may be modified to ½ in. square. In the case of plate ¾ in. or over in thickness, a ¾-in. round specimen machined from the material may be used. From plate 1½ in. or over in thickness, the specimen shall be taken midway between the center and surface of the plate.

Number of Tests

8. One tension and one bend test specimen shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be agreed upon between the manufacturer and the purchaser.

PERMISSIBLE VARIATIONS IN THICKNESS

9. The thickness of flat sheet, coiled or strip sheet, and plate, shall not vary from that specified by more than the respective tolerances indicated in the following table:

FLAT SHEET

	18 in. in Width and Under	Over 18 to 36 in., Incl., in Width	Over 36 to 54 in., Incl., in Width	Over 54 to 72 in., Incl., in Width	Over 72 to 90 in., Incl., in Width	Over 90 to 102 in., Incl., in Width
Thickness, in.	Thickness tolerance, plus or minus, in.					
0.250 to 0.129......	0.04T[a]	0.04T[a]	0.05T[a]	0.06T[a]	0.07T[a]	0.08T[a]
0.128 to 0.092......	0.004	0.0045	0.005	0.007	0.009	0.010
0.091 to 0.073......	0.003	0.003	0.004	0.006	0.008	......
0.072 to 0.051......	0.0025	0.003	0.004	0.005	0.007	......
0.050 to 0.037......	0.002	0.0025	0.003	0.004	......	......
0.036 to 0.018......	0.0015	0.002	0.0025	......	......	......
0.017 to 0.010......	0.0015	0.0015	0.002	......	......	......

COILED SHEET

	12 in. in Width and Under	Over 12 to 24 in., Incl., in Width	Over 24 in. in Width
Thickness, in.	Thickness tolerance, plus or minus, in.		
0.128 to 0.103....................	0.0035	0.0035	0.004
0.102 to 0.091....................	0.003	0.003	0.004
0.090 to 0.073....................	0.003	0.003	0.003
0.072 to 0.051....................	0.0025	0.003	0.003
0.050 to 0.041....................	0.0025	0.0025	0.0025
0.040 to 0.030....................	0.002	0.0025	0.0025
0.029 to 0.019....................	0.002	0.002	0.002
0.018 to 0.011....................	0.0015	0.002	......
0.010 to 0.008....................	0.001	0.0015	......
0.007 to 0.006....................	0.001	0.001	......

---

[a] T = the nominal thickness.

PLATE

THICKNESS, IN.	54 IN. IN WIDTH AND UNDER	OVER 54 TO 72 IN., INCL., IN WIDTH	OVER 72 TO 90 IN., INCL., IN WIDTH	OVER 90 TO 120 IN., INCL., IN WIDTH
	THICKNESS TOLERANCE, PLUS OR MINUS, PER CENT OF NOMINAL THICKNESS			
3.000 to 1.001	3	3	4	5
1.000 to 0.501	4	4	5	6
0.500 to 0.251	5	5	6	7
0.250 to 0.125	5	6	7	8

WORKMANSHIP AND FINISH

Workmanship and Finish

10. All sheet and plate shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

INSPECTION AND REJECTION

Inspection

11. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection

12. Materials which fail to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTES

NOTE 1.—In the case of sheet in the half-hard temper, there is an appreciable difference in the elongation depending upon the direction in which the test specimen is taken from the sheet. This measurement made parallel to the direction of final rolling is distinctly higher than if the specimen were cut perpendicular to this direction. This difference is not observed in hard or soft sheet. The inspection of half-hard sheet calls for the use of specimens parallel to the direction of final rolling because of the greater contrast with the values obtained from hard sheet. The fact that the bend-test specimens may be taken without regard to the direction of rolling is evidence that the lower elongation across the grain does not indicate a lack of workability.

NOTE 2.—The mechanical properties of "as rolled" plate lie between those of the soft temper and those of the half-hard temper. Thinner plates (up to about 0.5 in.), because of the cooling during the rolling operation, have strengths which average around the minimum for half-hard temper. As the thickness increases the properties approach those of the soft temper. Where higher properties are required it is more economical to use a stronger aluminum alloy rather than to specify an intermediate temper (half-hard or quarter-hard) because of the cost of cold rolling heavy plates.

NOTE 3.—The use of grips which insure a uniform axial loading of the test specimen is essential, if satisfactory results are to be obtained.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM-MANGANESE ALLOY SHEET AND PLATE[1]

A.S.T.M. Designation: B 79 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued as Tentative, 1930; Adopted, 1931; Reissued as Tentative, 1933; Revised, 1934.

Scope

1. These specifications cover aluminum-manganese alloy sheet and plate. Commercial flat sheet shall be supplied on orders for sheet, except where coiled or strip sheet is specifically ordered.

Manufacture

2. No scrap shall be used in the manufacture of aluminum-manganese alloy sheet and plate except such as shall accumulate at the manufacturer's plants from material of similar composition and of his own manufacture.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition

3. The sheet and plate shall conform to the following requirements as to chemical composition:

Aluminum, minimum, per cent	97.0
Manganese, per cent	1.0 to 1.5
Copper, maximum, per cent	0.2

Samples

4. Samples for analysis shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser. Samples for analysis may be obtained from the tension or bend test specimens described in Section 7. The sample for analysis may be prepared by shearing or by drilling or by machining without the use of any lubricant in such a manner as to give a sample representative of the entire cross-section of the sheet or plate. Samples

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

These specifications are in effect a revision of and replace the former Standard Specifications for Aluminum-Manganese Alloy Sheet (A.S.T.M. Designation: B 79 – 31) which were accordingly discontinued in 1933.

so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser and one for an umpire if necessary.

PHYSICAL PROPERTIES AND TESTS

Tensile Requirements

5. (*a*) Sheet shall be supplied in the temper specified in the contract or purchase order and shall conform to the following requirements as to tensile properties for the specified temper and thickness:

TEMPER	THICKNESS, IN.	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 2 IN., MINIMUM, PER CENT
Soft	0.013 to 0.031	19 000 max.	20
	0.032 to 0.050	19 000 max.	23
	0.051 to 0.250	19 000 max.	25
Half hard	0.013 to 0.019	19 500 min.	3[a]
	0.020 to 0.031	19 500 min.	4[a]
	0.032 to 0.050	19 500 min.	5[a]
	0.051 to 0.113	19 500 min.	6[a]
	0.114 to 0.161	19 500 min.	7
	0.162 to 0.250	19 500 min.	8
Three-quarter hard	0.013 to 0.019	23 500 min.	1
	0.020 to 0.031	23 500 min.	2
	0.032 to 0.050	23 500 min.	3
	0.051 to 0.162	23 500 min.	4
Hard	0.013 to 0.019	27 000 min.	1
	0.020 to 0.031	27 000 min.	2
	0.032 to 0.050	27 000 min.	3
	0.051 to 0.128	27 000 min.	4

---

[a] This value is required for flat sheet. For coiled sheet in the half-hard temper, the elongation may be less than that for flat sheet by 1 per cent in 2 in. The maximum thickness of coiled or strip sheet commercially available in the half-hard temper is 0.080 in.

(*b*) Unless otherwise specified, plate (thicknesses 0.250 in. and over) shall be supplied as rolled (see Explanatory Note 2) and tension tests shall not be required.

(*c*) If so specified, plate shall be supplied in the soft temper in thicknesses from 0.250 to 3.000 in., in which case the tensile strength shall not exceed 19,000 lb. per sq. in. and the elongation shall not be less than 25 per cent in 2 in.

Bend Tests

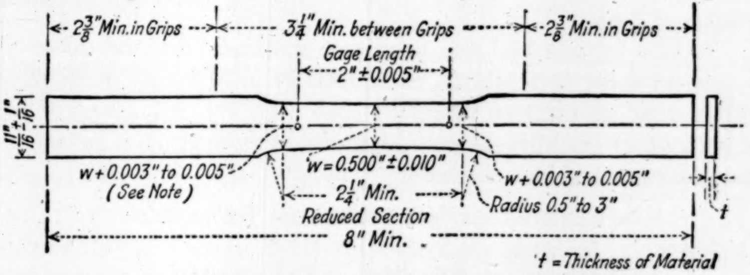
6. (*a*) Bend test specimens taken from sheet in the soft or in the half-hard temper or from plate in the soft temper or "as rolled" shall stand being bent cold through 180 deg. flat on themselves without cracking.

(*b*) Bend test specimens taken from sheet in the three-quarter-hard temper shall stand being bent cold through 180 deg. around a pin having a diameter equal to four times the thickness of the sheet without cracking.

(*c*) The bend test shall not be required for sheet in the hard temper.

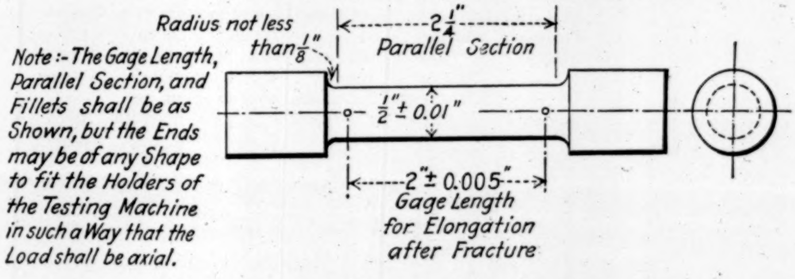
Test Specimens

7. (*a*) *Tension Test Specimens.*—Tension test specimens for sheet in the half-hard temper shall be taken parallel to the direction of rolling; for sheet in the soft, three-quarter-hard and hard tempers the tension test specimens may be taken in any direction. (See Explanatory Notes 1 and 3.) For sheet and plate under 0.500 in. in thickness the standard sheet tension test specimen shown in Fig. 1 shall be used. For plate 0.500 in. or over in thickness, the standard 0.505-in. diameter round specimen shown in Fig. 2 or a similar round specimen having the maximum possible dimensions proportional to those of the standard 0.505-in. diameter specimen shall be used.


$2\frac{3}{8}$" Min. in Grips
$3\frac{1}{4}$" Min. between Grips
$2\frac{3}{8}$" Min. in Grips
Gage Length
2" ± 0.005"
$\frac{11}{16}$" ± $\frac{1}{16}$"
w + 0.003" to 0.005"
(See Note)
w = 0.500" ± 0.010"
$2\frac{1}{4}$" Min.
Reduced Section
w + 0.003" to 0.005"
Radius 0.5" to 3"
8" Min.
t
t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.
All Machining Dimensions are Shown below and Testing Dimensions above Specimen.
The ends shall be symmetrical within 0.01 in.

FIG. 1.—Standard Tension Test Specimen for Sheet Metals.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2" ± 0.005"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Tension Test Specimen.

(*b*) *Bend Test Specimens.*—Bend test specimens may be taken in any direction from sheet in the soft, half-hard or three-quarter-hard temper and from plate in the soft temper or as rolled. Bend test specimens from thin sheet and strip shall be of the full thickness, and in the case of strips 1 in. in width or under, of the full width of the material. The width of specimens from material over 1 in. in width shall be six times the thickness, but not less than 1 in. The edges may be rounded to a $\frac{1}{16}$-in. radius. When practicable the length shall be at least 6 in. For plates over 0.500 in. in thickness a machined bend test specimen 1 by $\frac{1}{2}$ in. in cross-section and at least 6 in. in length shall be used. The edges may be rounded to a $\frac{1}{16}$-in. radius. When permitted by the inspector, the cross-section may be modified to $\frac{1}{2}$ in. square. In the case of plate $\frac{3}{4}$ in. or over in thickness, a $\frac{3}{4}$-in. round specimen machined from the material may be used. From plate $1\frac{1}{2}$ in. or over in thickness, the specimen shall be taken midway between the center and surface of the plate.

Number of Tests

8. One tension and one bend test specimen shall be taken from a random sheet to represent each 1000 lb. (453.6 kg.) of sheet, and from a random plate to represent each 2000 lb. (907.2 kg.) of plate, or such other quantity as may be mutually agreed upon between the manufacturer and the purchaser.

PERMISSIBLE VARIATIONS IN THICKNESS

Thickness

9. The thickness of flat sheet, coiled or strip sheet, and plate, shall not deviate from that specified by more than the respective tolerances indicated in the following table:

FLAT SHEET

THICKNESS, IN.	18 IN. IN WIDTH AND UNDER	OVER 18 TO 36 IN., INCL., IN WIDTH	OVER 36 TO 54 IN., INCL., IN WIDTH	OVER 54 TO 72 IN., INCL., IN WIDTH	OVER 72 TO 90 IN., INCL., IN WIDTH	OVER 90 TO 102 IN., INCL., IN WIDTH
	THICKNESS TOLERANCE, PLUS OR MINUS, IN.					
0.250 to 0.129	0.04T[a]	0.04T[a]	0.05T[a]	0.06T[a]	0.07T[a]	0.08T[a]
0.128 to 0.092	0.004	0.0045	0.005	0.007	0.009	0.010
0.091 to 0.073	0.003	0.003	0.004	0.006	0.008	......
0.072 to 0.051	0.0025	0.003	0.004	0.005	0.007	......
0.050 to 0.037	0.002	0.0025	0.003	0.004	......	......
0.036 to 0.018	0.0015	0.002	0.0025	......	......	......
0.017 to 0.010	0.0015	0.0015	0.002	......	......	......

[a] T = the nominal thickness.

COILED SHEET

THICKNESS, IN.	12 IN. IN WIDTH AND UNDER	OVER 12 TO 24 IN., INCL., IN WIDTH	OVER 24 IN. IN WIDTH
	THICKNESS TOLERANCE, PLUS OR MINUS, IN.		
0.128 to 0.103	0.0035	0.0035	0.004
0.102 to 0.091	0.003	0.003	0.004
0.090 to 0.073	0.003	0.003	0.003
0.072 to 0.051	0.0025	0.003	0.003
0.050 to 0.041	0.0025	0.0025	0.0025
0.040 to 0.030	0.002	0.0025	0.0025
0.029 to 0.019	0.002	0.002	0.002
0.018 to 0.011	0.0015	0.002	......
0.010 to 0.008	0.001	0.0015	......
0.007 to 0.006	0.001	0.001	......

PLATE

	54 IN. IN WIDTH AND UNDER	OVER 54 TO 72 IN., INCL., IN WIDTH	OVER 72 TO 90 IN., INCL., IN WIDTH	OVER 90 TO 120 IN., INCL., IN WIDTH
THICKNESS, IN.	THICKNESS TOLERANCE, PLUS OR MINUS, PER CENT OF NOMINAL THICKNESS			
3.000 to 1.001	3	3	4	5
1.000 to 0.501	4	4	5	6
0.500 to 0.251	5	5	6	7
0.250 to 0.125	5	6	7	8

WORKMANSHIP AND FINISH

Workmanship and Finish

10. All sheet and plate shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

INSPECTION AND REJECTION

Inspection

11. The manufacturer shall afford the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection

12. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTES

NOTE 1.—In the case of sheet in the half-hard temper, there is an appreciable difference in the elongation depending upon the direction in which the test specimen is taken from the sheet. This measurement made parallel to the direction of final rolling is distinctly higher than if the specimen were cut perpendicular to this direction. This difference is not observed in hard or soft sheet. The inspection of half-hard sheet calls for the use of specimens parallel to the direction of final rolling because of the greater contrast with the values obtained from hard sheet. The fact that the bend test specimens may be taken without regard to the direction of rolling is evidence that the lower elongation across the grain does not indicate a lack of workability.

NOTE 2.—The mechanical properties of "as rolled" plate lie between those of the soft temper and those of the half-hard temper. Thinner plates (up to about 0.5 in.), because of the cooling during the rolling operation, have strengths which average around the minimum for half-hard temper. As the thickness increases the properties approach those of the soft temper. Where higher properties are required it is more economical to use a stronger aluminum alloy rather than to specify an intermediate temper (half-hard or quarter-hard) because of the cost of cold rolling heavy plates.

NOTE 3.—The use of grips which insure a uniform axial loading of the test specimen is essential, if satisfactory results are to be obtained.

TENTATIVE SPECIFICATIONS
FOR
MAGNESIUM-BASE ALLOY FORGINGS[1]

A.S.T.M. Designation: B 91 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1932; REVISED, 1934.

Scope

1. These specifications cover fully-worked (see Explanatory Note 1) commercial magnesium-base alloy forgings having a specific gravity of 1.9 or less. Five alloys are specified and are designated Alloys Nos. 6, 7, 8, 9, and 10 (see Explanatory Note 2).

Manufacture

2. The alloys may be made from virgin metal or from purified scrap metal of known composition.

Chemical Composition

3. The forgings shall conform to the following requirements as to chemical composition:

Alloy	Magnesium, per cent	Aluminum, per cent	Manganese, min., per cent	Zinc, per cent	Copper, max., per cent	Tin, per cent	Silicon, max., per cent	Other Impurities,[a] max., per cent
No. 6.........	remainder	3.5 to 5.0	0.20	0.3 max.	0.10	....	0.5	0.3
No. 7.........	remainder	5.0 to 7.0	0.15	0.3 max.	0.10	....	0.5	0.3
No. 8.........	remainder	5.8 to 7.2	0.15	0.5to1.0	0.10	....	0.5	0.3
No. 9.........	remainder	7.8 to 9.2	0.15	0.2to0.8	0.10	....	0.5	0.3
No. 10.........	remainder	....	0.80	......	0.05	5.0 to 7.0	0.5	0.3

[a] Nickel, max., 0.05 per cent.

Sampling

4. The sample for chemical analysis may be taken by sawing, drilling, or milling and shall represent the average cross-section of the piece. The tool shall be thoroughly cleaned and no lubricant shall be used in the sampling operation. The sample shall weigh not less than 50 g.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

Tension Tests

5. The forgings shall conform to the following requirements as to tensile properties:

Alloy	Tensile Strength, min., lb. per sq. in.	Yield Strength[a] (Set = 0.2 per cent), min., lb. per sq. in.	Elongation in 2 in., min., per cent
No. 6	34 000	19 000	6.0
No. 7	34 000	19 000	6.0
No. 8	38 000	22 000	6.0
No. 9	42 000	24 000	5.0
No. 10	33 000	18 000	5.0

[a] See Explanatory Note 3.

Test Specimens

6. Tension test specimens shall be taken in such a manner that the longitudinal axis of the specimen is parallel to the direction of the maximum flow of the metal in the forging and where practicable shall be taken from a full-size prolongation of the forging. The specimen may be machined to the form and dimensions shown in Fig. 1, or in the case of thin material may be machined to the form and dimensions shown in Fig. 2, or may be the full section of the material.

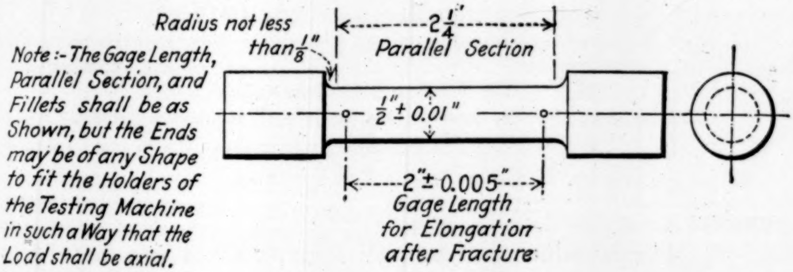

Note :- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.
Radius not less than 1/8"
2 1/4" Parallel Section
1/2" ± 0.01"
2" ± 0.005" Gage Length for Elongation after Fracture

Fig. 1.—Standard 2-in. Gage Length Tension Test Specimen.

Number of Tests

7. Two tension test specimens shall be taken to represent each 500 lb. or fraction thereof, or such other quantities as may be mutually agreed upon between the manufacturer and purchaser.

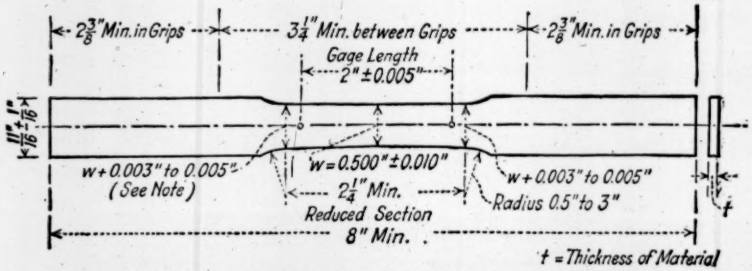
Workmanship and Finish

8. All material shall be of uniform quality, free from injurious surface defects and shall have a workmanlike finish.

Inspection

9. (*a*) Inspection may be made at the manufacturer's works where the material is made, or at the point at which it is received, at the option of the purchaser.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.



t = Thickness of Material

Note: Gradual Taper from Ends of Reduced Section to Middle.

All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 2.—Tension Test Specimen.

Rejection

10. Material which fails to meet these specifications may be rejected, and if rejected, the manufacturer's responsibility shall be limited to replacing the rejected material without charge to the purchaser. The full weight of the rejected material shall be returned to the manufacturer.

EXPLANATORY NOTES

NOTE 1.—The expression "fully worked" refers to material that has been worked sufficiently during the forging operations to develop maximum properties. Material that has been given smaller amounts of working will have correspondingly lower properties. Forging operations develop the maximum properties without the necessity of subsequent heat treatment.

NOTE 2. *Alloy No. 6.*—This alloy has a specific gravity of about 1.77. It is used for hot-press forgings and for hammer forgings of simple design. The forgeability of this alloy is superior to that of Alloys Nos. 7, 8, and 9, but its physical properties average somewhat lower. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 7.—This alloy has a specific gravity of about 1.79. It is used for hot-press forgings. It is quite similar to Alloy No. 6, but is somewhat more difficult to forge and its properties average slightly higher. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 8.—This alloy has a specific gravity of about 1.81. It is used for hot-press forgings. The properties of this alloy average somewhat higher than Alloys Nos. 6 and 7, and its resistance to salt-water corrosion is somewhat better than Alloys Nos. 6, 7, and 9. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 9.—This alloy has a specific gravity of about 1.83. It is used for hot-press forgings of simple design requiring maximum properties. It has lower forgeability than the other alloys specified. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 10.—This alloy has a specific gravity of about 1.85. It is used for hot-hammer forgings for moderately stressed parts. Resistance to salt-water corrosion is distinctly superior to that of the other alloys specified. The copper and nickel contents should be kept low to minimize corrosion.

NOTE 3.—The yield strength of magnesium-base alloys is defined as the stress at which the stress-strain curve deviates 0.2 per cent from the modulus line. It may be determined by the "Set Method" or the "Approximate Method Without the Stress-strain Diagram" (the latter is often referred to as the "Extension Under Load Method") as described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

The following unit deformations for use with the "Approximate Method" are based on a modulus of elasticity, $E = 6,500,000$ lb. per sq. in.:

ALLOY	YIELD STRENGTH (SET = 0.2 PER CENT), MIN., LB. PER SQ. IN.	UNIT DEFORMATION, INCH PER INCH OF GAGE LENGTH
No. 6	19 000	0.0049
No. 7	19 000	0.0049
No. 8	22 000	0.0054
No. 9	24 000	0.0057
No. 10	18 000	0.0048

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

TENTATIVE SPECIFICATIONS
FOR
MAGNESIUM-BASE ALLOY INGOT FOR REMELTING[1]

A.S.T.M. Designation: B 93 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover commercial magnesium-base alloys in ingot form for remelting (Note 1). These alloys have a specific gravity of 1.9 or less. Eleven alloys are specified and are designated Alloys Nos. 1 to 11, inclusive (Note 2).

NOTE 1.—Magnesium-base alloy ingots for remelting are normally furnished in the form of ingots 4 in. in diameter by 16 in. in length (approximate weight equals 12 lb.), unless otherwise specified in the contract.

NOTE 2.—Explanatory Notes pertaining to the alloys covered by these specifications when used in the form of die castings, sand castings, sheet, and forgings are given in connection with the following tentative specifications of the American Society for Testing Materials:[2] Tentative Specifications for Magnesium-Base Alloy Die-Castings (A.S.T.M. Designation: B 94 – 34 T); for Magnesium-Base Alloy Sand Castings (A.S.T.M. Designation: B 80 – 34 T); for Magnesium-Base Alloy Sheet (A.S.T.M. Designation: B 90 – 34 T); and for Magnesium-Base Alloy Forgings (A.S.T.M. Designation: B 91 – 34 T).

Manufacture

2. (*a*) The alloys may be made from virgin metal or from purified scrap metal of known composition.

(*b*) The ingots shall be uniform in quality and shall be commercially free from slag or other foreign material.

Chemical Composition

3. The alloys shall conform to the following requirements as to chemical composition.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light-Metals and Alloys, Cast and Wrought.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] See pp. 703, 684, 688 and 678.

Alloy	Magnesium, per cent	Aluminum, per cent	Manganese, min., per cent	Zinc, per cent	Copper, per cent	Cadmium, per cent	Tin, per cent	Silicon, max., per cent	Other Impurities,[a] max., per cent
No. 1....	remainder	7.3 to 8.7	0.18	....	0.08 max.	....	....	0.2	0.3
No. 2....	remainder	9.4 to 10.6	0.13	....	0.08 max.	....	....	0.2	0.3
No. 3....	remainder	11.5 to 12.5	0.13	....	0.08 max.	....	....	0.2	0.3
No. 4....	remainder	5.5 to 6.5	0.18	2.7 to 3.3	0.08 max.	....	....	0.2	0.3
No. 5....	remainder	1.7 to 2.3	0.20	....	3.3 to 4.7	1.7 to 2.3	....	0.2	0.3
No. 6....	remainder	3.6 to 4.8	0.25	....	0.08 max.	....	....	0.2	0.3
No. 7....	remainder	5.3 to 6.7	0.20	....	0.08 max.	....	....	0.2	0.3
No. 8....	remainder	6.0 to 7.0	0.20	0.5 to 1.0	0.08 max.	....	....	0.2	0.3
No. 9....	remainder	8.0 to 9.0	0.18	0.2 to 0.8	0.08 max.	....	....	0.2	0.3
No. 10....	remainder	....	0.90	....	0.05 max.	....	5.3 to 6.7	0.1	0.2
No. 11....	remainder	....	1.30	....	0.05 max.	....	....	0.1	0.2

[a] Nickel, max., 0.05 per cent.

Sampling

4. The sample for chemical analysis may be taken by sawing, drilling, or milling and shall represent the average cross-section of the ingot. The tool shall be thoroughly cleaned and no lubricant shall be used in the sampling operation. The sample shall weigh not less than 50 g.

Rejection

5. Material which fails to conform to the requirements of these specifications may be rejected, and if rejected, the manufacturer's responsibility shall be limited to replacing the rejected material without charge to the purchaser. The full weight of the rejected material shall be returned to the manufacturer.

TENTATIVE SPECIFICATIONS

FOR

MAGNESIUM-BASE ALLOY SAND CASTINGS[1]

A.S.T.M. Designation: B 80 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1930; REVISED, 1931, 1934.

Scope

1. These specifications cover commercial magnesium-base alloy sand castings having a specific gravity of 1.9 or less. Five alloys are specified and are designated Alloys Nos. 1, 2, 3, 4, and 5 (see Explanatory Note 1).

Manufacture

2. (*a*) The alloys may be made from virgin metal or from purified scrap metal of known composition.

(*b*) Castings made from Alloys Nos. 1, 2, and 3 may be subjected to such heat treatment as the manufacturer desires to produce material that will conform to the requirements specified. Heat treatment shall be performed on the whole of a casting, never on a part only, and shall be applied in a manner that will produce the utmost uniformity.

Chemical Composition

3. The castings shall conform to the following requirements as to chemical composition:

Alloy	Magnesium, per cent	Aluminum, per cent	Manganese, min., per cent	Zinc, per cent	Copper, per cent	Cadmium, per cent	Silicon, max., per cent	Other Impurities,[a] max., per cent
No. 1............	remainder	7.0 to 9.0	0.15	0.3 max.	0.10 max.	....	0.5	0.3
No. 2............	remainder	9.0 to 11.0	0.10	0.3 max.	0.10 max.	....	0.5	0.3
No. 3............	remainder	11.2 to 12.8	0.10	0.3 max.	0.10 max.	....	0.5	0.3
No. 4............	remainder	5.3 to 6.7	0.15	2.5 to 3.5	0.10 max.	....	0.5	0.3
No. 5............	remainder	1.5 to 2.5	0.15	0.3 max.	3.0 to 5.0	1.5 to 2.5	0.5	0.3

[a] Nickel, max., 0.05 per cent.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

Sampling

4. The sample for chemical analysis may be taken by sawing, drilling, or milling the casting or tension test specimen and shall represent the average cross-section of the piece. The tool shall be thoroughly cleaned and no lubricant shall be used in the sampling operation. The sample shall weigh not less than 50 g.

Tension Tests

5. The tension test specimens representing the castings shall conform to the following requirements as to tensile properties:

ALLOY	CONDITION	TENSILE STRENGTH, MIN., LB. PER SQ. IN.	ELONGATION IN 2 IN., MIN., PER CENT
No. 1	As-cast	23 000	3
	Heat Treatment No. 1[a]	29 000	6
No. 2	Heat Treatment No. 1[a]	29 000	5
	Heat Treatment No. 2[b]	29 000	2
	Heat Treatment No. 3[c]	29 000	not required
No. 3	Heat Treatment No. 3[c]	27 000	not required
No. 4	As-cast	24 000	4
No. 5	As-cast	21 000	3

---

[a] Heat Treatment No. 1—solution heat treatment.

[b] Heat Treatment No. 2—solution heat treatment plus partial aging.

[c] Heat Treatment No. 3—solution heat treatment plus complete aging.

Test Specimens

6. The tension test specimens shall be separately cast in green sand and shall be "cast to size" according to the dimensions shown in Fig. 1. If the castings are heat treated, the tension test specimens representing such castings shall be similarly heat treated. They shall not be machined prior to test except to adapt the grips to the holders of the testing machine in such a manner as to insure an axial load.

Number of Tests

7. (*a*) The tests shall be made, so far as possible, by heats or melts, but unless otherwise mutually agreed upon by the manufacturer and purchaser, two tension tests shall be made for each unit of 500 lb. or fraction thereof.

(*b*) If any tension test specimen is improperly machined or shows flaws upon testing, it may be discarded; in which case the manufacturer and the purchaser, or his representative, may agree upon the selection of another specimen in its stead.

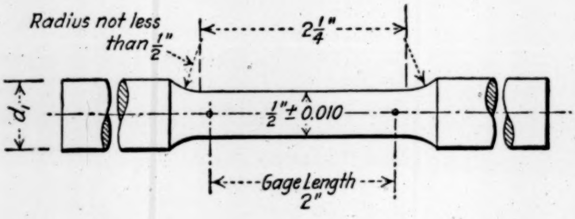
Workmanship and Finish

8. The castings shall be of uniform quality and condition, free from cracks or other injurious defects, and shall be well cleaned before inspection by sand-blasting or any other approved process.

Inspection

9. (*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.



NOTE:

The Gage Lengtn, Parallel Section and Fillets shall be as shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a way, that the Load shall be Axial.

In Order to promote the Breaking of the Specimen in the Center it is permissible to use a Taper in the Reduced Section from the Fillets to the Center of not to exceed 0.010 in.

It is recommended, that Diameter d_1 be from $\frac{3}{4}$" to 1."

FIG. 1.—Tension Test Specimen.

Rejection

10. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected and, if rejected, the manufacturer's responsibility shall be limited to replacing the rejected material without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

EXPLANATORY NOTES

NOTE 1. *Alloy No. 1.*—This alloy has a specific gravity of about 1.80. It has higher impact strength and elongation and lower yield strength than Alloy No. 2. It is used in the as-cast condition for castings subjected to moderate stresses and in the solution heat-treated condition (H. T. No. 1) for castings requiring maximum toughness and elongation. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 2.—This alloy has a specific gravity of about 1.81. It is used both in the solution heat-treated condition (H. T. No. 1) and in the solution heat-treated and aged conditions (H. T. No. 2 and H. T. No. 3). Aging increases the yield strength and hardness and decreases the toughness and elongation. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 3.—This alloy has a specific gravity of about 1.82. It is used in the solution heat-treated and aged condition (H. T. No. 3) for castings requiring the maximum obtainable yield strength. Toughness and elongation are low. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 4.—This alloy has a specific gravity of about 1.84. It is used only in the as-cast condition. Its properties are approximately the same and its resistance to salt-water corrosion is somewhat better than the as-cast Alloy No. 1. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 5.—This alloy has a specific gravity of about 1.86. Its thermal conductivity is 50 to 75 per cent greater than that of Alloys Nos. 1 to 4, inclusive, and is recommended where this property is of importance. It should not be used for other purposes because of its relatively poor corrosion resistance.

NOTE 2.—The yield strength of magnesium-base alloys is defined as the stress at which the stress-strain curve deviates 0.2 per cent from the modulus line. It may be determined by the "Set Method" or the "Approximate Method Without the Stress-strain Diagram" (the latter is often referred to as the "Extension Under Load Method") as described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

The following data give typical yield strength values for the various alloys, together with the corresponding unit deformations for use with the "Approximate Method" based on a modulus of elasticity, $E = 6{,}500{,}000$ lb. per sq. in.:

ALLOY	CONDITION	TYPICAL YIELD STRENGTH (SET = 0.2 PER CENT), LB. PER SQ. IN.	UNIT DEFORMATION, INCH PER INCH OF GAGE LENGTH
No. 1	As-cast	11 000	0.0037
	Heat Treatment No. 1[a]	11 000	0.0037
No. 2	Heat Treatment No. 1[a]	12 000	0.0038
	Heat Treatment No. 2[b]	16 000	0.0045
	Heat Treatment No. 3[c]	19 000	0.0049
No. 3	Heat Treatment No. 3[c]	21 000	0.0052
No. 4	As-cast	11 000	0.0037
No. 5	As-cast	8 000	0.0032

[a] Heat Treatment No. 1—solution heat treatment.

[b] Heat Treatment No. 2—solution heat treatment plus partial aging.

[c] Heat Treatment No. 3—solution heat treatment plus complete aging.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

TENTATIVE SPECIFICATIONS
FOR
MAGNESIUM-BASE ALLOY SHEET[1]

A.S.T.M. Designation: B 90 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1932; REVISED, 1934.

Scope

1. These specifications cover commercial magnesium-base alloy sheet having a specific gravity of 1.8 or less. Two alloys are specified and are designated Alloys Nos. 6 and 11 (see Explanatory Note 1).

Manufacture

2. The alloys may be made from virgin metal or from purified scrap metal of known composition.

Chemical Composition

3. The sheet shall conform to the following requirements as to chemical composition:

Alloy	Magnesium, per cent	Aluminum, per cent	Manganese, min., per cent	Copper, max., per cent	Zinc, max., per cent	Silicon, max., per cent	Other Impurities,[a] max., per cent
No. 6..........	remainder	3.5 to 5.0	0.20	0.10	0.3	0.5	0.3
No. 11..........	remainder	....	1.20	0.05	....	0.3	0.3

[a] Nickel, max., 0.05 per cent.

Sampling

4. The sample for chemical analysis may be taken by sawing, shearing, or machining and shall represent the average cross-section of the sheet. The tool shall be thoroughly cleaned and no lubricant

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-7 on Light Metals and Alloys, Cast and Wrought.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

shall be used in the sampling operation. The sample shall weigh not less than 50 g.

Tension Tests

5. The sheet shall conform to the following requirements as to tensile properties:

ALLOY	CONDITION	TENSILE STRENGTH, LB. PER SQ. IN.	YIELD STRENGTH[a] (SET = 0.2 PER CENT), MIN., LB. PER SQ. IN.	ELONGATION IN 2 IN., MIN., PER CENT
No. 6....	Hard Rolled (H)	36 000 min.	25 000	4
	Annealed (A)	38 000 max.	......	10
No. 11....	Heat Treated (T)	35 000 max.	......	12
	Heat Treated and Rolled (TR)	32 000 min.	24 000	4

[a] See Explanatory Note 2.

Test Specimens

6. The tension test specimens may be cut in any direction irrespective of the direction of rolling and shall be machined to the form and dimensions shown in Fig. 1.

Number of Tests

7. Two tension test specimens shall be taken to represent each 500 lb. or fraction thereof, or such other quantities as may be mutually agreed upon between the manufacturer and purchaser.

Permissible Variations in Dimensions

8. *Thickness Tolerances.*—The thickness of sheets shall not vary from that specified by more than the following permissible variations:

THICKNESS, IN.	PERMISSIBLE VARIATIONS IN THICKNESS	
	SHEET UNDER 36 IN. IN WIDTH	SHEET 36 TO 50 IN. IN WIDTH
0.015 to 0.036	± 0.002 in.	± 0.0025 in.
0.037 to 0.050	± 0.0025 in.	± 0.003 in.
0.051 to 0.080	± 0.003 in.	± 0.004 in.
0.081 to 0.250	± 5 per cent of thickness	± 5 per cent of thickness

9. *Width Tolerances.*—The width of sheets shall not vary from that specified by more than the following permissible variations:

THICKNESS, IN.	PERMISSIBLE VARIATIONS IN WIDTH, IN.		
	SHEET 18 IN. AND UNDER IN WIDTH	SHEET OVER 18 TO 36 IN., INCL., IN WIDTH	SHEET 36 TO 50 IN. IN WIDTH
0.015 to 0.102	$\pm \frac{1}{16}$	$\pm \frac{3}{32}$	$\pm \frac{1}{8}$
0.103 to 0.250	$\pm \frac{3}{32}$	$\pm \frac{1}{8}$	$\pm \frac{3}{16}$

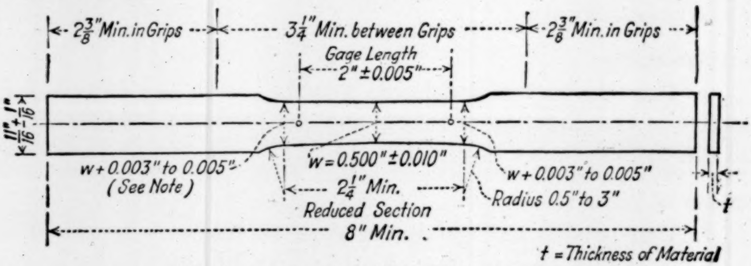
10. *Length Tolerances.*—(*a*) The length of sheets shall not vary from that specified by more than the following permissible variations:

THICKNESS, IN.	PERMISSIBLE VARIATIONS IN LENGTH, IN.			
	SHEET 18 IN. AND UNDER IN LENGTH	SHEET OVER 18 TO 48 IN., INCL., IN LENGTH	SHEET OVER 48 TO 120 IN., INCL., IN LENGTH	SHEET OVER 120 IN. IN LENGTH
0.015 to 0.250.....	$\pm \frac{1}{16}$	$\pm \frac{3}{32}$	$\pm \frac{1}{8}$	$\pm \frac{5}{32}$

(*b*) In case an exact length is specified, the permissible variation in length shall be $+\frac{1}{8}$ in. with no under tolerance.

Workmanship and Finish

11. All sheet shall be commercially flat and free from buckles, shall be free from injurious surface defects, and shall have a workmanlike finish.



Note: Gradual Taper from Ends of Reduced Section to Middle.

All Machining Dimensions are Shown below and Testing Dimensions above Specimen.

The ends shall be symmetrical within 0.01 in.

FIG. 1.—Standard Tension Test Specimen for Sheet Metals.

Inspection

12. (*a*) Inspection may be made at the manufacturer's works where the material is made, or at the point at which it is received, at the option of the purchaser.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection

13. Material which fails to meet these specifications may be rejected, and if rejected, the manufacturer's responsibility shall be limited to replacing the rejected material without charge to the purchaser. The full weight of the rejected material shall be returned to the manufacturer.

EXPLANATORY NOTES

NOTE 1. *Alloy No. 6.*—This alloy has a specific gravity of about 1.77. Its physical properties and forming characteristics are superior to those of Alloy No. 11. The copper and nickel contents should be kept low to minimize corrosion.

Alloy No. 11.—This alloy has a specific gravity of about 1.76. It is recommended where maximum resistance to salt-water corrosion is required. The copper and nickel contents should be kept low to minimize corrosion.

NOTE 2.—The yield strength of magnesium-base alloys is defined as the stress at which the stress-strain curve deviates 0.2 per cent from the modulus line. It may be determined by the "Set Method" or the "Approximate Method Without the Stress-strain Diagram" (the latter is often referred to as the "Extension Under Load Method") as described in the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

The following unit deformations for use with the "Approximate Method" are based on a modulus of elasticity, $E = 6{,}500{,}000$ lb. per sq. in.:

ALLOY	YIELD STRENGTH (SET = 0.2 PER CENT), MIN., LB. PER SQ. IN.	UNIT DEFORMATION INCH PER INCH OF GAGE LENGTH
No. 6	25 000	0.0058
No. 11	24 000	0.0057

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

TENTATIVE SPECIFICATIONS
FOR
COPPER-SILICON ALLOY PLATES AND SHEETS[1]

A.S.T.M. Designation: B 96 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Scope

1. These specifications cover rolled copper-silicon alloy plates and sheets for pressure vessels.

MANUFACTURE

Manufacture

2. The plates and sheets shall be manufactured by hot rolling or by hot and cold rolling from castings of suitable dimensions.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. The plates and sheets shall conform to the following requirements as to chemical composition:

Silicon, per cent	1.00 to 5.00
Manganese, max., per cent	1.50
Zinc, max., per cent	5.00
Iron, max., per cent	2.50
Tin, max., per cent	2.00
Aluminum, max., per cent	2.00
Other elements, max., per cent	0.50
Copper, per cent	remainder

Chemical Analysis

4. (*a*) Chemical analysis shall be made on each lot of 5000 lb. or fraction thereof.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

(*b*) The sample for chemical analysis shall be taken by drilling or milling representative plates or sheets in such a way that a sample of the entire thickness of the plates or sheets shall be obtained. Equal quantities from each of the plates and sheets sampled shall be thoroughly mixed. Samples so prepared shall be divided into three equal parts, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

5. The plates and sheets shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	55 000
Yield point,[a] lb. per sq. in.	22 500
Elongation in 2 in., per cent	40
Elongation in 8 in., per cent	25

[a] 0.50 per cent extension under stress.

Test Specimens

6. Tension test specimens shall be machined to conform to the dimensions shown in Fig. 6 or 7 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1] The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests

7. Unless otherwise specified, one tension test shall be made for every lot of 5000 lb. or fraction thereof of each gage or thickness of plates and sheets in the shipment.

PERMISSIBLE VARIATION IN WEIGHT

Permissible Variation in Weight

8. The permissible variation in weights for plates and sheets of all thicknesses and widths shall be ±$7\frac{1}{2}$ per cent.

WORKMANSHIP AND FINISH

Workmanship and Finish

9. The plates and sheets shall be free from injurious defects and shall have smooth, clean surfaces, unless otherwise specified. The fracture shall be uniform in color and grain throughout.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

MARKING

Marking

10. The name or brand of the manufacturer and the manufacturer's lot identification number shall be legibly stamped or stenciled on each finished plate and sheet in two places not less than 12 in. from the edges. If the plates and sheets are too small to locate the marking as above, the marking may be placed near the center of the plate and sheet. In the case of butt strap, the marking may be placed 12 in. from the end.

INSPECTION AND REJECTION

Inspection

11. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection

12. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
COPPER-SILICON ALLOY RODS, BARS AND SHAPES[1]

A.S.T.M. Designation: B 98 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Scope

1. These specifications cover copper-silicon alloy rods, bars and shapes of any cross-section uniform with respect to length.

MANUFACTURE

Manufacture

2. The rods, bars and shapes shall be manufactured by hot and/or cold working, finished by such cold rolling or drawing as may be required, and straightened.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. The rods, bars and shapes shall conform to the following requirements as to chemical composition:

Silicon, per cent	1.00 to 5.00
Manganese, max., per cent	1.50
Zinc, max., per cent	5.00
Iron, max., per cent	2.50
Tin, max., per cent	2.00
Aluminum, max., per cent	2.00
Other elements, max., per cent	0.50
Copper, per cent	remainder

Chemical Analysis

4. (*a*) Chemical analysis shall be made on each lot of 5000 lb., or fraction thereof.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

(*b*) Drillings or millings for chemical analysis shall be taken from at least four separate pieces, equal quantities being taken from each piece and thoroughly mixed. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

5. The material shall conform to the minimum requirements as to tensile properties shown in Table I.

TABLE I.—TENSION AND BEND TEST REQUIREMENTS.

TEMPER		TENSILE STRENGTH, LB. PER SQ. IN.	YIELD POINT,[a] LB. PER SQ. IN.	ELONGATION IN 2 IN., PER CENT	BEND TEST, ANGLE OF BEND, DEG.
	DIAMETER OR DISTANCE BETWEEN PARALLEL FACES	RODS			
Soft	All sizes	50 000	......	45.0	180
Hard	Up to ¼-in., incl	90 000	60 000	8.0	90
	Over ¼ to 1 in., incl	90 000	60 000	12.0	90
	Over 1 to 1½ in., incl	80 000	55 000	25.0	90
	Over 1½ to 3 in., incl	70 000	45 000	25.0	90
	THICKNESS	BARS			
Soft	All Sizes	50 000	......	45.0	180
Hard	Up to 1 in., incl	65 000	32 500	25.0	90
	Over 1 to 1½ in., incl	60 000	30 000	25.0	90
	Over 1½ to 3 in., incl	50 000	25 000	25.0	90
	TEMPER	SHAPES			
Soft	All sizes	50 000	......	45.0	180
Hard	All sizes	[b]	[b]	[b]	[b]

---

[a] 0.50 per cent extension under stress.

[b] As agreed between manufacturer and purchaser at time of order.

Bend Test

6. The bend test specimen shall stand being bent cold through the angle specified in Table I to a radius equal to its diameter or thickness, without fracturing.

Test Specimens

7. (*a*) Tension test specimens shall be as nearly as possible of the same diameter, or distance between parallel faces of the rods, bars or shapes.

(*b*) Bend test specimens may be a piece of full-size rod, shape or bar, or a piece 1 in. in width by ½ in. in thickness. In case of bend test specimens of rectangular section, the edges may be rounded off to a radius equal to one-fourth of the thickness.

Number of Tests

8. (*a*) Rods, bars or shapes shall be grouped into lots of not more than 5000 lb.

(*b*) One tension and one bend test specimen shall be cut from one rod, bar or shape from each lot or fraction thereof.

(*c*) If any part of the fracture of the tension test specimen is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

PERMISSIBLE VARIATIONS IN DIMENSIONS

Diameter or Thickness

9. (*a*) The diameter of round sections or the distance between parallel faces in the case of other sections, except shapes, shall not vary from that specified by more than the following:

DIAMETER OR THICKNESS, IN.	PERMISSIBLE VARIATIONS, IN.	
	COLD DRAWN	HOT WORKED
Up to and including 0.50	±0.0025	±0.005
Over 0.50 to 1, incl	±0.004	±0.008
Over 1 to 2.5, incl	±0.005	±0.010
Over 2.5	±0.0075	±0.015

(*b*) The permissible variations in dimensions for shapes shall be specified in the contract or purchase order.

Length

10. (*a*) Rods and bars, when ordered to any length, will be received in stock lengths, unless it is specifically stated that the lengths are to be exact.

(*b*) Stock lengths for all rods and bars up to and including 1 in. in diameter or thickness shall be as follows but the weight of lengths less than the length ordered shall not exceed 40 per cent of any one shipment:

ORDERED LENGTH, FT.	PERMISSIBLE VARIATION
12	no length less than 8 ft.
10	no length less than 6 ft.
8	no length less than 6 ft.
6	no length less than 4 ft.

(*c*) For rods and bars over 1 in. up to and including 2 in. in diameter or thickness, the lengths shall be random lengths from 4 to 10 ft.

(*d*) Rods and bars over 2 in. in diameter or thickness shall be ordered in special lengths.

WORKMANSHIP AND FINISH

Workmanship and Finish

11. The rods, bars and shapes shall be free from injurious defects, substantially straight and free from kinks and bends. Unless otherwise specified, they shall have a bright, smooth surface.

INSPECTION AND REJECTION

Inspection

12. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the rods, bars and shapes are being furnished in accordance with these specifications.

Rejection

13. Rods, bars and shapes which fail to conform to these specifications will be rejected and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
SHEET COPPER-SILICON ALLOY[1]

A.S.T.M. Designation: B 97 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Scope

1. These specifications cover sheet copper-silicon alloy, commonly used for drawing, forming, stamping and bending.

MANUFACTURE

Material

2. (*a*) The sheets shall be manufactured by hot working and cold rolling and annealing processes and may be furnished in either the cold rolled or annealed condition, as required.

(*b*) Clean, new scrap resulting from manufacturing operations upon materials complying with these specifications or composed of material of equal purity may be employed.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. The sheets shall conform to the following requirements as to chemical composition:

Silicon, per cent	1.00 to 5.00
Manganese, max., per cent	1.50
Zinc, max., per cent	5.00
Iron, max., per cent	2.50
Tin, max., per cent	2.00
Aluminum, max., per cent	2.00
Other elements, max., per cent	0.50
Copper, per cent	remainder

Chemical Analysis

4. (*a*) Chemical analysis shall be made on each lot of 5000 lb. or fraction thereof.

(*b*) The sample for chemical analysis shall be taken by drilling, milling or clipping representative coils or pieces. Drillings or millings shall be taken on material thicker than 0.040 in. Clippings may be taken with shears from metal thinner than 0.040 in. Equal quantities shall be taken from each piece or coil and thoroughly mixed together. Samples so prepared shall be divided into three equal parts, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

PHYSICAL PROPERTIES AND TESTS

5. (*a*) The sheets shall conform to the following minimum requirements as to physical properties:

TEMPER	MATERIAL AND SIZES	TENSILE STRENGTH, LB. PER SQ. IN	YIELD, POINT,[a] LB. PER SQ. IN.	ELONGATION IN 2 IN., PER CENT	BEND TEST, ANGLE OF BEND, DEG.
Soft........	Sheets and strips, all sizes...............	50 000	......	35.0	180
Half-hard...	Sheets and strips up to and including 18 in. in width...........	70 000	40 000	10.0	120
Hard.......	Sheets and strips up to and including 18 in. in width...........	80 000	60 000	5.0	90

[a] 0.50 per cent extension under stress.

(*b*) Special tempers of sheet copper-silicon alloy not covered by these specifications may be agreed upon between the manufacturer and purchaser, in which case they will be specifically defined in the purchase order so that the manufacturer will be able to supply material suitable for its intended use.

Bend Test

6. The bend test specimen shall stand being bent through the angle specified in the table in Section 5 to a radius not less than the thickness and not more than twice the thickness of the sheet, without fracturing.

Test Specimens

7. Tension test specimens shall be machined to conform to the dimensions shown in Fig. 6 or 7 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1] The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests

8. Unless otherwise specified, one tension test shall be made for every lot of 5000 lb. or fraction thereof of each gage or thickness of sheet in the shipment.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

PERMISSIBLE VARIATIONS IN WEIGHT AND DIMENSIONS

Width

9. (*a*) The width of slit metal shall not vary more than ±0.010 in.

(*b*) The width of sheared metal shall not vary more than $\pm\frac{1}{16}$ in.

Thickness

10. The standard method of specifying thickness shall be in terms of Brown & Sharpe gage. When thickness is specified in either common or decimal fractions of an inch, the permissible variations in thickness shall be those of a corresponding group of B. & S. gages shown in Table I.

TABLE I.—PERMISSIBLE VARIATIONS IN THICKNESS, PLUS OR MINUS, IN.

Thickness		Up to 6 in. in Width, inclusive	Over 6 to 9 in. in Width, inclusive	Over 9 to 14 in. in Width, inclusive	Over 14 to 20 in. in Width, inclusive
B. & S. Gage No.	Inch				
0000	0.4600	0.0054	0.0056	0.0059	0.0061
000	0.4096	0.0053	0.0055	0.0058	0.0060
00	0.3648	0.0051	0.0054	0.0056	0.0059
0	0.3249	0.0050	0.0053	0.0055	0.0058
1	0.2893	0.0049	0.0051	0.0054	0.0056
2	0.2576	0.0048	0.0050	0.0053	0.0055
3	0.2294	0.0046	0.0049	0.0051	0.0054
4	0.2043	0.0045	0.0048	0.0050	0.0053
5	0.1819	0.0044	0.0046	0.0049	0.0051
6	0.1620	0.0043	0.0045	0.0048	0.0050
7	0.1443	0.0041	0.0044	0.0046	0.0049
8	0.1285	0.0040	0.0043	0.0045	0.0048
9	0.1144	0.0039	0.0041	0.0044	0.0046
10	0.1019	0.0038	0.0040	0.0043	0.0045
11	0.0907	0.0036	0.0039	0.0041	0.0044
12	0.0808	0.0035	0.0038	0.0040	0.0043
13	0.0719	0.0034	0.0036	0.0039	0.0041
14	0.0640	0.0033	0.0035	0.0038	0.0040
15	0.0570	0.0031	0.0034	0.0036	0.0039
16	0.0508	0.0030	0.0033	0.0035	0.0038
17	0.0452	0.0029	0.0031	0.0034	0.0036
18	0.0403	0.0028	0.0030	0.0033	0.0035
19	0.0359	0.0026	0.0029	0.0031	0.0033
20	0.0320	0.0025	0.0026	0.0029	0.0030
21	0.0284	0.0024	0.0025	0.0026	0.0028
22	0.0253	0.0023	0.0024	0.0025	0.0026
23	0.0225	0.0021	0.0023	0.0024	0.0025
24	0.0201	0.0020	0.0021	0.0023	0.0024
25	0.0179	0.0019	0.0020	0.0021	0.0023
26	0.0159	0.0018	0.0019	0.0020	0.0021
27	0.0142	0.0016	0.0018	0.0019	0.0020
28	0.0126	0.0015	0.0016	0.0018	0.0019
29	0.0112	0.0014	0.0015	0.0016	0.0018
30	0.0100	0.0014	0.0015	0.0016	0.0018
31	0.0089	0.0013	0.0014	0.0015	0.0016
32	0.0079	0.0013	0.0014	0.0015	0.0016
33	0.0070	0.0011	0.0013	0.0014	0.0015
34	0.0063	0.0011	0.0013	0.0014	0.0015
35	0.0056	0.0010	0.0011	0.0013	0.0014
36	0.0050	0.0010	0.0011	0.0013	0.0014

Weight

11. When cold rolled or cold rolled and annealed, sheet copper-silicon alloy over 20 in. in width is specified, a permissible variation of $\pm 7\frac{1}{2}$ per cent of the theoretical weight of the sheet will be allowed.

Length

12. The material may be furnished in coils of flat strips as required. Coils shall consist of not more than three lengths, no one of which shall be less than 10 ft. long. When specific lengths are required they shall be specified in the order. When furnished in flat strips of exact length, a variation of $\frac{1}{16}$ in. over the specified length will be permitted on full length sheets.

Acceptable Short Lengths

13. Lengths of sheet copper-silicon alloy shall be in accordance with the following regular practice:

When ordered in lengths over 10 up to 12 ft. .	40 per cent may be 10 ft. and over. 30 per cent may be 8 to 10 ft. 20 per cent may be 6 to 8 ft. 10 per cent may be 4 to 6 ft. Not more than 40 per cent of any one shipment may be less than the length ordered.
When ordered in 10-ft. lengths.	40 per cent may be 8 ft. and over. 30 per cent may be 6 to 8 ft. 20 per cent may be 4 to 6 ft. 10 per cent may be 2 to 4 ft. Not more than 40 per cent of any one shipment may be less than 10 ft.
When ordered in 8-ft. lengths.	30 per cent may be 6 ft. and over. 20 per cent may be 4 to 6 ft. 10 per cent may be 2 to 4 ft. Not more than 30 per cent of any one shipment may be less than 8 ft.
When ordered in 6-ft. lengths.	20 per cent may be 4 ft. and over. 10 per cent may be 2 to 4 ft. Not more than 20 per cent of any one shipment may be less than 6 ft.

Finish

14. The sheet copper-silicon alloy shall be free from injurious external and internal defects of a nature which will interfere with the purpose for which it is intended. It shall be well cleaned and free from dirt.

Inspection and Rejection

15. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

16. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS

FOR

MAGNESIUM-BASE ALLOY DIE CASTINGS[1]

A.S.T.M. Designation: B 94 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover magnesium-base alloy die castings having a specific gravity of about 1.8. One alloy is specified and is designated as Alloy No. 2.

Manufacture

2. The alloy may be made from virgin metal or from purified scrap metal of known composition.

Chemical Composition

3. The castings shall conform to the following requirements as to chemical composition:

Magnesium, min., per cent	88.0
Aluminum, per cent	9.0 to 11.0
Manganese, min., per cent	0.10
Copper, max., per cent	0.10
Nickel, max., per cent	0.05

Sampling

4. (*a*) Samples for check analyses shall be taken either by sawing, drilling, or milling a representative group of castings, and shall represent the average cross section of the material. The sample shall weigh not less than 50 g.

(*b*) The saw, drill, cutter, or other tool used shall be thoroughly cleaned. No lubricant shall be used in the sampling operation.

Workmanship and Finish

5. The castings shall be of uniform quality and shall be produced with smooth surfaces, free from cracks and disfiguring blemishes.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-6 on Die-Cast Metals and Alloys.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

Rejection

6. Die castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected the manufacturer's responsibility shall be limited to replacing rejected castings without charge to the purchaser.

EXPLANATORY NOTES

NOTE 1.—The data in the following table covering Alloy No. 2 do not constitute a part of these specifications. They will indicate to the purchaser the physical properties that may be expected of tension and impact test specimens when made in a die, the test specimens being cast in regular production routine and conforming to the dimensions shown in Figs. 1 and 2 and to the chemical composition specified. Rockwell hardness values have not been shown because they are considered too unreliable on die castings.

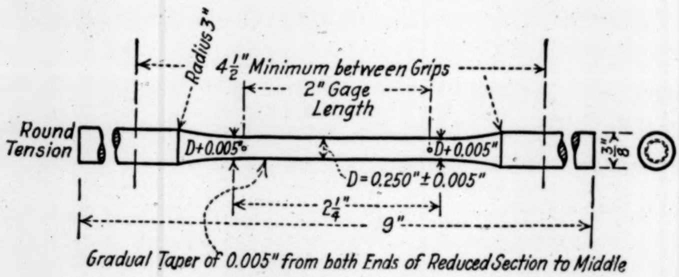

Radius 3"
4½" Minimum between Grips
2" Gage Length
Round Tension
D+0.005"
D+0.005"
3/8"
D=0.250"±0.005"
2¼"
9"
Gradual Taper of 0.005" from both Ends of Reduced Section to Middle

FIG. 1.—Round Tension Test Specimen.

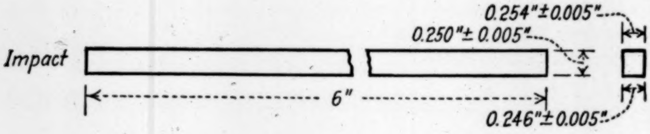

0.254"±0.005"
0.250"± 0.005"
Impact
6"
0.246"±0.005"

FIG. 2.—Charpy Impact Test Specimen.

Tensile strength, lb. per sq. in.	26 000 to 30 000
Elongation in 2 in., per cent	1 to 3
Charpy impact, ft-lb	1 to 3

NOTE 2.—Alloy No. 2, as specified in these specifications, corresponds to Alloy No. 2 in the Tentative Specifications for Magnesium-Base Alloy Ingot for Remelting (B 93 – 34 T) of the American Society for Testing Materials.[1]

---

[1] See p. 682.

The aluminum content has been set at 9.0 to 11.0 per cent. Alloys with lower aluminum content have somewhat higher percentage elongation and Charpy impact values but have lower fluidity and, hence, are more difficult to cast. Alloys with higher aluminum content are too brittle for many purposes.

Manganese is added to this type of alloy in order to improve corrosion resistance, particularly against salt water and salt-water atmosphere. Manganese is only slightly soluble in an alloy of this type and 0.10 per cent has been found sufficient to obtain the desired results. The alloy will usually contain 0.15 to 0.30 per cent manganese, although a manganese content in excess of this amount is not detrimental.

The copper and nickel contents are set at 0.10 and 0.05 per cent, respectively, inasmuch as larger percentages of these elements decrease the corrosion resistance of the alloy.

The present phraseology for expressing the composition of these magnesium-base die castings permits the allowable presence of appreciable amounts of metals such as silicon, zinc, cadmium, and tin that are often present in other magnesium-base alloys and which in small quantities have no detrimental effects on magnesium-base alloy die castings. Such metals, therefore, should not be classed as impurities.

TENTATIVE SPECIFICATIONS

FOR

ZINC-BASE ALLOY DIE CASTINGS[1]

A.S.T.M. Designation: B 86 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1931; REVISED, 1933, 1934.[2]

Scope

1. These specifications cover commercial die castings, die cast from zinc-base alloys. Two alloy compositions are specified, designated alloys Nos. XXI[3] and XXIII.

MANUFACTURE

Process

2. (*a*) The alloys may be made by any approved method.

(*b*) The casting shall be of uniform quality and no scrap shall be used other than the sprues, gates, rejected castings, etc., of the particular alloy, which are produced in the manufacturer's own plant. The rejected castings used shall be free from finishes, solder, or inserts which may contaminate the alloy.

Base Metal

3. The base metal for the alloys shall be slab zinc conforming to the requirements for the special high grade of the Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6) of the American Society for Testing Materials.[4]

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee B-6 on Die-Cast Metals and Alloys.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

[3] **This alloy designation corresponds to the number used in the investigation on zinc-base die-casting alloys carried out under the jurisdiction of Committee B-6 on Die-Cast Metals and Alloys (formerly Subcommittee XV on Die-Cast Metals and Alloys of Committee B-2 on Non-Ferrous Metals and Alloys). See *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 192 (1929).**

[4] **1933 Book of A.S.T.M. Standards, Part I, p. 858.**

CHEMICAL COMPOSITION AND TESTS

Chemical Composition

4. The alloys shall conform to the following requirements as to chemical composition:

	ALLOY No. XXI	ALLOY No. XXIII
Copper, per cent	2.5 to 3.5	0.10, max.
Aluminum, per cent	3.5 to 4.5	3.5 to 4.3
Magnesium, per cent	0.02 to 0.10	0.03 to 0.08
Iron, max., per cent	0.100	0.100
Lead, max., per cent	0.007	0.007
Cadmium, max., per cent	0.005	0.005
Tin, max., per cent	0.005	0.005
Zinc, per cent	remainder	remainder

Sampling

5. (*a*) The sample for chemical analysis may be taken either by sawing, drilling, or milling the casting or tension test specimen, and shall represent the average cross-section of the piece.

(*b*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawings or metal chips shall be carefully treated with a magnet to remove any particles of iron introduced in taking the sample.

PHYSICAL PROPERTIES AND TESTS

Expansion

6. (*a*) The average expansion of any five or more castings or test specimens after being exposed to water vapor at 95 C. for 10 days shall not exceed the following values:

	ALLOY No. XXI	ALLOY No. XXIII
Expansion per inch, max., in.	0.0025	0.0010

NOTE.—A maximum expansion of the amount permitted in 1 in. is allowable in any dimension less than 1 in. Dimensions shall be measured across solid sections of the casting.

(*b*) The humidity cabinet shall be vented, and shall contain no wood or organic matter. The specimens shall be supported at points outside of the test section by glass, porcelain, zinc, or zinc-coated metal.

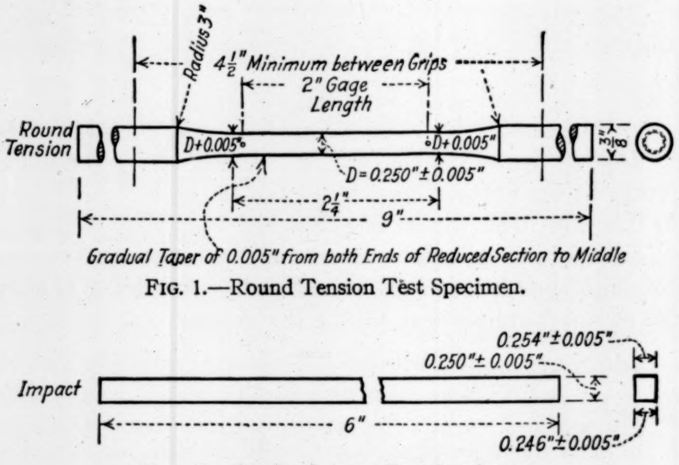
Optional Tests

7. Unless specified in the order or specifically guaranteed by the manufacturer, acceptance of castings under these specifications shall not depend on physical properties determined by tension or impact tests.

Physical Properties

8. When specified, the test specimens representing the alloy shall conform to the following requirements as to physical properties in the condition as received from the manufacturer:

	AVERAGE OF FIVE SPECIMENS		INDIVIDUAL SPECIMENS	
	ALLOY NO. XXI	ALLOY NO. XXIII	ALLOY NO. XXI	ALLOY NO. XXIII
Tensile strength, min., lb. per sq. in.....	44 000	35 000	35 000	30 000
Elongation in 2 in., min., per cent......	2.0	3.0	0.5	2.0
Charpy impact, min., ft-lb.............	6.0	12.0	4.0	8.0



Gradual Taper of 0.005" from both Ends of Reduced Section to Middle

FIG. 1.—Round Tension Test Specimen.

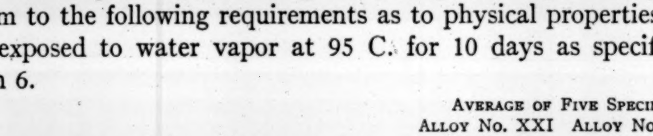


FIG. 2.—Charpy Impact Test Specimen.

Stability

9. When specified, the test specimens representing the alloy shall conform to the following requirements as to physical properties after being exposed to water vapor at 95 C. for 10 days as specified in Section 6.

	AVERAGE OF FIVE SPECIMENS	
	ALLOY NO. XXI	ALLOY NO. XXIII
Tensile strength, min., lb. per sq. in...........	30 000	30 000
Elongation in 2 in., min., per cent.............	0.5	1.5
Charpy impact, min., ft-lb....................	0.75	12.0

Test Specimens

10. (*a*) The test specimens shall be die cast according to the dimensions shown in Figs. 1 and 2 and shall be tested without machining. No ejector pins shall be used on reduced sections. Specimens shall be removed from dies as soon as cast and cooled in still air with gates attached.

Defective Bars

(*b*) Impact test specimens shall be made by cutting the 6-in. bar into two pieces 3 in. in length. The anvil of the testing machine shall have a 40-mm. span. The larger width of the test specimen shall be placed against the anvil.

(*c*) In case any of the test specimens contain a flaw or flaws which results in failure of the alloy to meet the specifications, the manufacturer and purchaser shall agree upon the selection of specimens for retests, or the defective bars shall be disregarded.

Number of Tests

11. Five of each type of test specimen shall be tested.

Soundness

12. Heavy section die castings are subject to spongy centers. The extent of this sponginess if objectionable shall be mutually agreed upon by the manufacturer and purchaser for each individual casting.

WORKMANSHIP AND FINISH

Finish

13. The die casting shall be produced free from cracks and other disfiguring blemishes.

REJECTION

Rejection

14. Die castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected the manufacturer's responsibility shall be limited to replacing rejected parts without charge to the purchaser.

TENTATIVE METHODS OF CHEMICAL ANALYSIS OF METALLIC MATERIALS FOR ELECTRICAL HEATING[1]

A.S.T.M. Designation: B 71 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1927; REVISED, 1928, 1929, 1933, 1934.

DETERMINATION OF NICKEL

SOLUTIONS REQUIRED

1. The following reagents will be required:

Concentrated Sulfuric Acid (sp. gr. 1.84).

Concentrated Nitric Acid (sp. gr. 1.42).

Concentrated Hydrochloric Acid (sp. gr. 1.19).

Dilute Sulfuric Acid (1:1).—Slowly stir 100 ml. of H_2SO_4 (sp. gr. 1.84) into 100 ml. of water.

Dilute Sulfuric Acid (1:99).—Slowly stir 10 ml. of H_2SO_4 (sp. gr. 1.84) into 990 ml. of water.

Tartaric Acid (20 per cent).

Ammonium Hydroxide (sp. gr. 0.90).

Dilute Acetic Acid (1:3).—Mix 1 ml. of acetic acid (sp. gr. 1.04) and 3 ml. of water.

Dilute Nitric Acid (1:3).—Mix 100 ml. of HNO_3 (sp. gr. 1.42) and 300 ml. of water.

Nitro-Hydrochloric Acid.—Mix 10 ml. of HNO_3 (sp. gr. 1.42), 30 ml. of HCl (sp. gr. 1.19) and 40 ml. of water.

Sodium Dimethylglyoxime.—Dissolve 3 g. of dimethylglyoxime in 100 ml. of NaOH (3 per cent), made fresh each time used.

Potassium Thiocarbonate.—Saturate with H_2S one half of 250 ml. of a 5 per cent solution of KOH, add the other half and heat moderately with one twenty-fifth of its volume of CS_2. Decant the dark red liquid from the undissolved CS_2 and preserve in a well closed flask.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys.

METHOD

2. (*a*) Dissolve exactly 1 g. of the alloy sample in 20 ml. of nitrohydrochloric acid in a covered 600-ml. beaker. Add 20 ml. of dilute H_2SO_4 (1:1) and evaporate the liquid carefully to fumes of sulfur trioxide. When the beaker and its contents have cooled, add 100 ml. of water and allow the solution to digest at a low heat until all salts have dissolved. Filter the solution on a 9-cm. paper to remove any silica and wash the paper and residue thoroughly with hot water or, if an insoluble residue is present, wash with dilute H_2SO_4 (1:99). Ignite the precipitate at a low heat and treat with 2 ml. of HF and several drops of H_2SO_4 (1:1) in a platinum crucible, and evaporate to dryness. Fuse the residue with a little sodium carbonate, dissolve in HCl and add to the main nickel solution.

Transfer the nickel solution to a 250-ml. graduated flask and dilute to the mark with cold water. Mix and draw off exactly 50 ml. by means of an accurately calibrated pipette, and transfer this aliquot portion to a 600-ml. beaker. This aliquot portion represents 0.2 g. of the original sample. Add 250 ml. of cold water and 25 ml. of a 20 per cent solution of tartaric acid (enough to hold all the iron and chromium in solution), make the solution alkaline with NH_4OH, and then make it acid with an excess of 15 ml. of HCl (sp. gr. 1.19). Add 20 ml. (for the 60 per cent nickel alloy) to 30 ml. (for the 80 per cent nickel alloy) of a freshly prepared solution of sodium dimethylglyoxime, and make the solution ammoniacal, and then make it just acid with dilute acetic acid (1:3). Stir the solution vigorously and allow it to stand at a temperature of from 75 to 90° C. with occasional stirring for 30 minutes. If an alcoholic solution of dimethylglyoxime is used to precipitate the nickel, digest the contents of the beaker at a temperature just short of the boiling point until the odor of alcohol can no longer be detected. From 65 to 100 ml. of a 1 per cent alcoholic solution of dimethylglyoxime will be required.

Filter the scarlet precipitate of nickel dimethylglyoxime on a tared Gooch crucible. Wash thoroughly with hot water and dry at from 105 to 110° C. to constant weight. Cool in a desiccator and weigh.

Calculation.—The weight of nickel dimethylglyoxime multiplied by 20.32 and again by 5 gives the percentage of nickel in the sample. Treat the filtrate with 10 ml. of HCl (sp. gr. 1.19) and approximately 5 ml. of sodium dimethylglyoxime and again adjust with ammonia and acetic acid as previously described in order to make certain of the complete precipitation of the nickel. This method yields results that are correct to within ±0.35 per cent.

(*b*) If greater accuracy is desired, use a larger aliquot portion with proportionally larger amounts of reagents, filter the nickel dimethylglyoxime precipitate on a 15-cm. paper and wash thoroughly eighteen or twenty times with hot water. Dissolve the precipitate off the paper with boiling dilute HNO_3 (1:3) and wash the filter thoroughly with hot water. Add 10 ml. of dilute H_2SO_4 (1:1) and boil the liquid gently until strong fumes of sulfur trioxide are evolved. Having allowed the beaker and its contents to cool somewhat, add 10 ml. of HNO_3 (sp. gr. 1.42) and repeat the evaporation. Rinse the cover and sides of the beaker with a fine jet of water and fume the solution again to insure the expulsion of every trace of the HNO_3. When cool, add approximately 50 ml. of cold water and boil the contents of the beaker for several minutes, which should result in a perfectly clear solution.

Neutralize with NH_4OH and add an excess of 25 ml. of NH_4OH (sp. gr. 0.90). Now electrolyze the nickel sulfate solution with a current of from 1 to 2 amperes, using a weighed platinum gauze cathode and a spiral platinum anode. Continue the electrolysis until the solution has become colorless and then continue for at least 15 minutes longer. Now test the solution by adding one or two drops of it to a solution of potassium thiocarbonate. A pink or red color indicates the presence of nickel. The amount of the solution withdrawn for this test will not affect the results and may be neglected. This test will show whether or not the electrolysis has been completed. Wash the metal deposited on the cathode with water while the current is flowing. Remove the cathode and dip it first into a beaker of distilled water and then into absolute alcohol, dry for a few minutes at a temperature of from 80 to 100° C., and weigh.

Calculation.—The increase in weight of the cathode multiplied by 100 and divided by the weight of the sample taken gives the percentage of nickel in the sample. In the case of very accurate work, dissolve the deposit off the cathode with warm HNO_3 (sp. gr. 1.42), wash the cathode with water, then alcohol, dry for a few minutes at 80° C. and reweigh.

DETERMINATION OF CHROMIUM
BY THE
PERSULFATE METHOD

SOLUTIONS REQUIRED

3. The following reagents will be required:

Silver Nitrate Solution (0.5 per cent).—Dissolve 5 g. of $AgNO_3$ in 1000 ml. of water.

Ammonium Persulfate.

Phosphoric Acid (sp. gr. 1.72).

Potassium Permanganate (2.5 per cent).

Sodium Chloride (10 per cent).—Dissolve 100 g. of NaCl in 1000 ml. of water.

Perchloric Acid (60 per cent).

Sulfuric Acid (1:1).—Slowly stir 500 ml. of H_2SO_4 (sp. gr. 1.84) into 500 ml. of water.

Nitric Acid (sp. gr. 1.42).

Standard Ferrous Ammonium Sulfate Solution.—Dissolve 39.25 g. of ferrous ammonium sulfate in distilled water, containing 20 ml. of dilute H_2SO_4 (1:1). Dilute to 1 liter, mix thoroughly and standardize against 0.1 *N* potassium permanganate, which has in turn been standardized against the U. S. Bureau of Standards sodium oxalate. This solution should be standardized just before using, as its value may change from day to day. One cubic centimeter of 0.1 *N* solution is equivalent to 0.001733 g. of chromium.

Standard Potassium Permanganate Solution (0.1 N).—Dissolve approximately 3.18 g. of pure potassium permanganate in 300 ml. of hot distilled water, boil for 10 or 15 minutes, cool to room temperature and filter on asbestos. Transfer the solution to a glass-stoppered bottle and allow it to stand for two weeks, at the end of which time filter again on asbestos and transfer to a liter flask and dilute to the mark. This solution should be kept in a dark bottle. After a preliminary standardization against the U. S. Bureau of Standards sodium oxalate, dilute so as to be exactly 0.1 *N*, and verify this strength by a second comparison with sodium oxalate.

METHOD

4. Treat 1 g. of the sample in a covered 600-ml. beaker with 10 ml. of perchloric acid (60 per cent). Heat to strong fumes of perchloric acid to aid in the solution of the alloy, and continue the heating for 3 or 4 minutes after the alloy has dissolved completely to insure the oxidation of the larger part of the chromium to the sexivalent state. Add 100 ml. of hot water and heat to boiling for several minutes to expel chlorine. Remove from the plate and add 20 ml. of dilute H_2SO_4 (1:1) and 5 ml. of HNO_3 (sp. gr. 1.42). Dilute to 250 ml. with hot water, add 10 ml. of $AgNO_3$ (0.5 per cent), 3 g. of ammonium persulfate and 5 or 6 drops of $KMnO_4$ solution (2.5 per cent). Boil for 5 minutes or longer, add 20 ml. of NaCl solution (10 per cent) and boil for 10 minutes after the permanganic acid or any manganese dioxide formed has dissolved completely, in order to

make sure that all chlorine has been expelled. Cool to room temperature and dilute with cold water to 400 ml. Treat with 2 ml. of H_3PO_4 (sp. gr. 1.72), add from a burette standardized ferrous ammonium sulfate until the solution turns green, and then add 5 ml. in excess. Titrate this excess back with 0.1 *N* potassium permanganate.

5. *Calculation.*—Calculate the percentage of chromium from the following formula:

$$\text{Percentage of chromium} = \frac{[(A \times B) - C] \times 0.001733}{\text{weight of sample}} \times 100$$

where *A* = the volume in cubic centimeters of ferrous ammonium sulfate used;

B = the normality factor of ferrous ammonium sulfate, determined daily;

C = the volume in cubic centimeters of exactly 0.1 *N* potassium permanganate used.

DETERMINATION OF IRON

SOLUTIONS REQUIRED

6. The following reagents will be required:

Perchloric Acid (60 per cent).

Dilute Hydrochloric Acid (1:4).—Mix 25 ml. of HCl (sp. gr. 1.19) and 100 ml. of water.

Ammonium Hydroxide (sp. gr. 0.90).

Ammonium Persulfate.

Stannous Chloride Solution.—Dissolve 50 g. of stannous chloride in 100 ml. of HCl (sp. gr. 1.19) and dilute to 1000 ml.

METHOD

7. For alloys containing 10 per cent or more of iron, use a 1-g. sample, and for alloys containing 2 per cent or less of iron, use a 3-g. sample. Treat the sample in a 500-ml. Erlenmeyer flask fitted with a Meyer bulb or trap with 20 to 50 ml. of perchloric acid (60 per cent) at a temperature of 203° C. or higher until the alloy has dissolved completely, and continue the boiling of the acid for five minutes longer to aid in the complete oxidation of the chromium to the sexivalent state. The tall flask and bulb (or trap) are used to prevent the loss of $FeCl_3$ by volatilization, which happens if a covered beaker is used. Add approximately 200 ml. of hot water, an excess of about 10 ml. of NH_4OH (sp. gr. 0.90) and 5 g. of ammonium persulfate. Boil for 5 minutes, filter and wash thoroughly with hot

water. Dissolve the $Fe(OH)_3$ in hot HCl (1:4) and repeat the precipitation with NH_4OH and ammonium persulfate, and the filtration. Dissolve the iron precipitate in the least possible amount (15 to 25 ml.) of boiling, dilute HCl (1:4) and wash the filter thoroughly with water. Heat to boiling, add stannous chloride solution slowly and with stirring to discharge the yellow color of the ferric chloride and to provide a few drops in excess. Finish the determination by the Zimmerman-Reinhardt method.[1]

DETERMINATION OF MANGANESE

SOLUTIONS REQUIRED

8. The following reagents will be required:

Perchloric Acid (60 per cent).

Nitric Acid (sp. gr. 1.135).

Nitric Acid (3 per cent).—Mix 3 ml. of HNO_3 (sp. gr. 1.42) and 100 ml. of water.

Ammonium Hydroxide (sp. gr. 0.90).

Ammonium Persulfate.

Sodium Bismuthate.

Sulfurous Acid.

Standard Ferrous Ammonium Sulfate Solution.—Prepare as described in Section 3 under the Determination of Chromium by the Persulfate Method. One cubic centimeter of 0.1 *N* solution is equivalent to 0.001099 g. manganese.

Standard Potassium Permanganate Solution (0.1 N).—Prepare as described in Section 3 under the Determination of Chromium by the Persulfate Method.

METHOD

9. Treat exactly 1 g. of the sample in a covered 600-ml. beaker with 20 ml. of perchloric acid (60 per cent) at a temperature of 203° C. or higher until the alloy has dissolved completely, and continue the boiling of the acid for 5 minutes longer to completely oxidize the chromium. Add 200 ml. of warm water, an excess of about 10 ml. of NH_4OH (sp. gr. 0.90) and 5 g. of ammonium persulfate. Boil for 5 minutes, filter on two superimposed 11-cm. filter papers, supported on a Büchner funnel, gentle suction being employed. Wash the precipitate thoroughly with hot water. Dissolve the precipitate of ferric hydroxide and manganese peroxide in 75 ml. of hot HNO_3 (sp. gr. 1.135) and a few drops of sulfurous acid. Wash the filter thoroughly with hot water. Repeat the precipitation with NH_4OH and ammonium persulfate, and the filtration. Dissolve the pre-

---

[1] A. A. Blair, "The Chemical Analysis of Iron," Vol. 8, p. 248.

cipitate in 50 ml. of hot HNO_3 (sp. gr. 1.135) and a few drops of sulfurous acid, and wash the filter with HNO_3 of the same strength. Transfer to a 300-ml. Erlenmeyer flask and boil for several minutes to expel oxides of nitrogen. Treat cautiously with 0.5 g. of sodium bismuthate and heat to boiling for 1 or 2 minutes. Clear with a sufficient excess of sulfurous acid and boil for 2 or 3 minutes longer. Cool to 15° C., add 1 to 2 g. of sodium bismuthate, shake vigorously for 1 minute, dilute with an equal volume of cold water and filter at once on an ignited asbestos or alundum filter. Wash with cold 3 per cent HNO_3. Add from a burette 20 to 35 ml. (depending on the amount of permanganic acid) of ferrous ammonium sulfate solution and titrate the excess with standard $KMnO_4$ solution.

10. *Calculation.*—Calculate the percentage of manganese from the following formula:

$$\text{Percentage of manganese} = \frac{[(A \times B) - C] \times 0.001099}{\text{weight of sample}} \times 100$$

where A = the volume in cubic centimeters of ferrous ammonium sulfate used;

B = the normality factor of ferrous ammonium sulfate, determined daily;

C = the volume in cubic centimeters of exactly 0.1 N potassium permanganate used.

DETERMINATION OF CARBON
BY THE
DIRECT COMBUSTION METHOD

Direct combustion of these alloys in oxygen at approximately 1100° C. yields only part of the total carbon. To effect complete oxidation of the carbon the sample must, previous to ignition in oxygen, be mixed with some oxidizing agent or accelerator. Many materials have been proposed and are used for this purpose, among which may be mentioned iron, steel or tin filings of low-carbon content. The evolved carbon dioxide is absorbed in ascarite (asbestos impregnated with sodium hydroxide) and weighed. Reference should be made to the Determination of Carbon by the Direct-Combustion Method, as described in the Standard Methods of Chemical Analysis of Plain Carbon Steel (A.S.T.M. Designation: A 33) of the American Society for Testing Materials.[1]

SAMPLE

11. The sample shall consist of at least ten factor weights (one factor weight equals 0.2727 g.) and shall be rather finely divided in order that such a large sample may be placed in the combustion boat. In case the carbon exceeds 0.05 per cent, a five factor weight sample

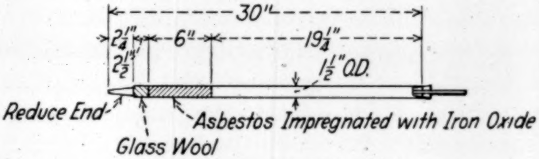
---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 326.

shall be used. Care must be taken in placing the sample in the trench, as its proper distribution is of considerable importance. With all samples, close packing in a small space is conducive to rapid and complete combustion. The usual precautions shall be used in obtaining a perfectly clean sample.

APPARATUS

12. (*a*) *Boats and Lining Material.*—Zirkite boats 4 in. long by $\frac{3}{4}$ in. wide by $\frac{3}{8}$ in. deep (inside dimensions) are the most satisfactory, although alundum, nickel, or porcelain boats may be used. The boats shall be ignited in a muffle furnace before using. The bottom of the boat shall be lined with a trench of 90-mesh RR alundum which is especially prepared for carbon determinations. The sample shall be covered with a very thin layer of alundum. Some alundum powder shall be sprinkled inside of the combustion tube to prevent the boat from sticking.


30"
2¼"
6"
19¼"
2½"
1½" O.D.
Reduce End
Glass Wool
Asbestos Impregnated with Iron Oxide

Detail of Tube F

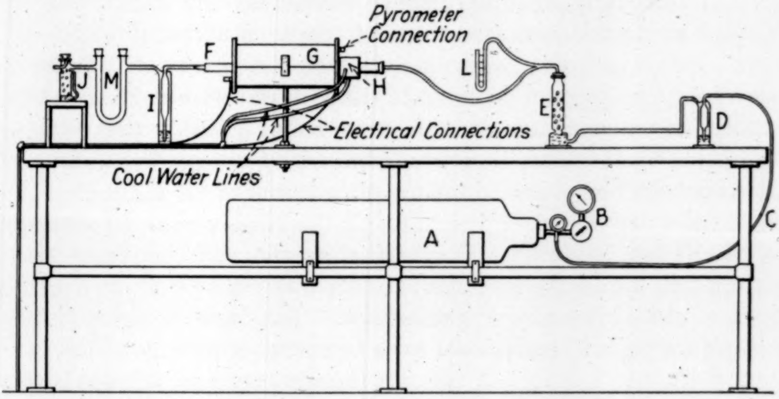

Pyrometer Connection
F
G
H
J
M
I
L
E
D
Electrical Connections
Cool Water Lines
B
C
A

FIG. 1.—Apparatus for the Determination of Carbon by the Combustion Method.

(*b*) *Flux.*—Exactly 2 g. (or a weight equal to that of the sample) of fine drillings of ingot iron or tin filings of known carbon content shall be sprinkled over the sample before the alundum is placed over the top of the whole charge.

(*c*) *Furnace and Combustion Tube.*—The standard electric combustion furnace in common use may be used, but as the temperatures are considerably higher the life of the heating element will be shorter than usual. A pyrometer shall always be used. A fused-silica or porcelain tube 30 in. in length and 1½ in. in diameter gives the best results. The front end of the tube shall be encased in a water-cooled jacket. The rear or reduced end of the tube shall be packed with glass wool for a length of 2½ in. and then with asbestos impregnated with ferric oxide (prepared by saturating the asbestos with a solution of ferric nitrate and igniting overnight at 1000° C. or higher) for a length of about 6 in. Ferric oxide will serve to oxidize any carbon monoxide formed and will convert any sulfur dioxide to ferric sulfate.

(*d*) *Detailed Description of Apparatus.*—Figure 1 illustrates the details of the apparatus. Oxygen from the 100 cu. ft. cylinder *A* passes through the reducing valve *B* to the H_2SO_4 (sp. gr. 1.84) bottle *D*, thence to the soda lime tube *E* to the furnace. From the furnace the gases pass through the tower *I* which is filled with H_2SO_4 (sp. gr. 1.84) to a depth of 2½ in. to remove moisture. The H_2SO_4 must be changed at regular intervals of about ten days under normal usage. From the tower *I* the gases pass through the U-tube *M* filled with anhydrone (magnesium perchlorate trihydrate) to insure the complete removal of all moisture and also any sulfur trioxide that escaped absorption by the asbestos impregnated with ferric oxide. A layer of glass wool shall be placed in the top of each arm of the U-tube. From the U-tube *M*, the gases pass through the Nesbit bulb *J* containing ascarite (12 to 30-mesh). A layer of glass wool shall be placed in the bottom and top of the bulb, and the ascarite shall be covered with a layer of anhydrone about ½ in. thick. The bulb, tower and tube shall be connected very closely so as to minimize passage of the gases through rubber tubing. A mercury manometer *L* which has a 6-in. scale with ¼-in. subdivisions shall be used for indicating the pressure, and, when calibrated, the rate of flow of the oxygen. The manometer shall be calibrated by measuring the oxygen passing through the train at a given pressure, either by metering or collecting over water. The rate of flow of the oxygen shall be held at 400 to 600 ml. per minute, after combustion of the sample.

METHOD

13. The furnace shall be heated to approximately 1100° C.; a sample of low-carbon steel is then burned in oxygen and the evolved carbon dioxide absorbed in the ascarite bulb, *J*. Weigh the ascarite bulb and connect it as shown in Fig. 1, quickly insert the boat (con-

taining the sample), by means of a copper rod, into the hottest part of the furnace and immediately replace the stopper. Allow the boat and its contents to heat for about one minute with no oxygen passing; this will result in some oxygen being absorbed by the iron, and the H_2SO_4 in the tower *I* will be drawn back into the large bulb as a consequence of the partial vacuum resulting therefrom. At the expiration of about 1 minute, admit oxygen to the tube at such a rate that the manometer will show a difference in level of $1\frac{1}{2}$ in. This should cause the iron to burn with vivid incandescence and result in complete combustion of the iron in the alloy in from $1\frac{1}{2}$ to 2 minutes. During the burning of the sample the mercury manometer shall be held at a difference in level of $1\frac{1}{2}$ in. and so maintained to the end of the operation. The pressure corresponds, normally, to an oxygen flow of 400 to 600 ml. per minute. Should varying resistance in the train change this ratio, a higher or lower pressure shall be maintained so as to give approximately the same flow of oxygen. The preliminary heating followed by the rapid admission of oxygen is absolutely essential to securing complete combustion. Only in case the oxides are so thoroughly fused as to show no trace of the shape of the original drillings when the boat is removed from the furnace, shall the combustion be considered successful.

At the conclusion of the above described operations (6 minutes after the boat was inserted into the furnace), close the stopper in *J* and remove the absorption bottle, cool for about 1 minute and weigh. The stopper is loosened for relief of vacuum for a second or so just before the completion of the weighing. In weighing the absorption bottle, a similar bottle filled with ascarite, but weighing slightly less, is used for a counterpoise. The counterpoise bottle is always kept close to the absorption bottle so as to be exposed to exactly the same conditions of humidity, temperature, etc.

Run a blank on the ingot iron, boat, etc., and deduct any carbon so found from that obtained in the analysis.

Allowable Error.—Percentages of carbon determined by the above method should be accurate to ±0.01 per cent. If greater accuracy is desired, the combustion shall be conducted at a temperature of from 1150 to 1200° C. or even higher.

DETERMINATION OF INSOLUBLE RESIDUE

METHOD

14. The sample should weigh at least 5 g. and if the alloy is known to be low in insoluble residue a 10-g. sample should be used. Treat the sample with from 200 to 400 ml. of HCl (sp. gr. 1.19) at a

temperature of from 60 to 70° C. until the reaction appears to be complete, then add 1 to 2 ml. of HNO_3 (sp. gr. 1.42). Boil the solution for about 2 minutes, dilute with an equal volume of hot water, filter, and wash the filter thoroughly with hot dilute HCl (5:95).

Ignite the residue at a low heat in a platinum crucible, treat with HF and several drops of dilute H_2SO_4 (1:1), and evaporate the solution just to fumes of sulfur trioxide. If any residue remains, add 10 ml. of water to the crucible, filter on a 9-cm. paper and wash the residue with hot water. Ignite any residue remaining on the paper and weigh.

15. *Calculation.*—The increase in weight multiplied by 100 and divided by the weight of sample taken gives the percentage of insoluble residue.

Accuracy.—In the case of an insoluble residue of 0.05 per cent, duplicate determinations should check within ±0.02 per cent insoluble residue.

DETERMINATION OF SILICON

METHOD

16. Treat a two to five factor weight sample (one factor weight equals 0.4672 g.) in a covered 300-ml. porcelain casserole with 15 to 35 ml. of perchloric acid (60 per cent) at a temperature of 203° C. (the boiling point of the acid) until the alloy has dissolved completely, and continue the boiling for 10 minutes longer. Add 100 ml. of warm water, boil for several minutes and filter on an 11-cm. paper of close texture. Wash six or eight times with hot water, once with sulfurous acid (10 per cent) to reduce any chromic acid held in the filter, and then thoroughly with hot water.

Ignite the paper and precipitate in a small platinum crucible, first at a dull red heat until the carbon of the filter paper has been oxidized, and finally at 1050 to 1100° C. Allow the crucible to cool in a desiccator and weigh. Add one or two drops of H_2SO_4 (1:1), several milliliters of HF, and evaporate the solution until all the H_2SO_4 has been expelled. Ignite the crucible again at 1050 to 1100° C., cool and weigh.

17. *Calculation.*—The difference between the first and the second weights multiplied by 100 and divided by the weight of sample taken gives the percentage of silicon in the sample.

DETERMINATION OF SULFUR
BY THE
EVOLUTION-TITRATION METHOD

This method is based on (1) the evolution of practically all the sulfur in the alloy as hydrogen sulfide when the alloy is dissolved in HCl (sp. gr. 1.19) (see Note); (2) absorption of the evolved gas by means of an ammoniacal solution of cadmium chloride; and (3) determination of the sulfur by titration with a standard solution of potassium iodate (0.0312 *N*).

SOLUTIONS REQUIRED

18. The following reagents will be required:

Potassium Permanganate Solution (2.5 per cent).—Dissolve 2.5 g. of $KMnO_4$ in 100 ml. of water.

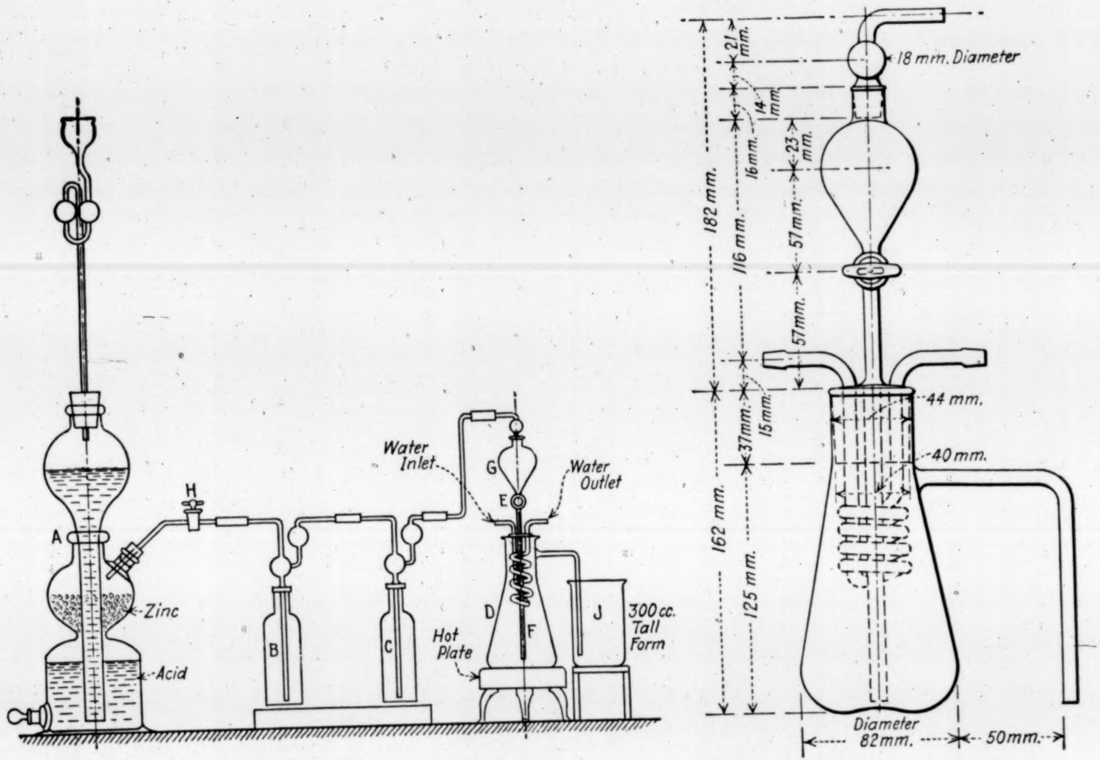
Sodium Hydroxide (30 per cent).—Dissolve 30 g. of NaOH in 100 ml. of water.

Cadmium Chloride Solution.—Dissolve 10 g. of $CdCl_2 \cdot 2H_2O$ in 400 ml. of water and 600 ml. of NH_4OH (sp. gr. 0.90).

Starch Solution.—Dissolve 1.2 g. of soluble starch in 100 ml. of boiling water, cool to room temperature and add a solution of 0.5 g. of KI dissolved in 10 ml. of cold, freshly distilled water. The starch solution shall not be used if it is over one day old.

Standard Potassium Permanganate (0.03 N).—Dissolve 0.99 g. of pure $KMnO_4$ in 1000 ml. of hot distilled water, boil for 10 minutes, cool to room temperature and filter through asbestos. Standardize against the U. S. Bureau of Standards standard sodium oxalate as follows: In a 200-ml. beaker, dissolve 0.1 g. of sodium oxalate in 75 to 100 ml. of hot water (80 to 90° C.) and add 4 ml. of H_2SO_4 (1:1). Titrate at once with the permanganate solution, stirring the liquid vigorously and continuously. The permanganate must not be added more rapidly than 10 to 15 ml. per minute, and the last 0.5 to 1 ml. must be added dropwise, with particular care to allow each drop to be fully decolorized before the next is introduced. The excess of permanganate used to cause an end-point color must be estimated by matching the color in another beaker containing the same bulk of acid and hot water. The temperature of the solution should not be below 60° C. by the time the end point is reached. Calculate the exact normality of potassium permanganate from the sodium oxalate.

Standard Sodium Thiosulfate (0.03 N).—Dissolve 7.5 g. of $Na_2S_2O_3 \cdot 5H_2O$ in 1000 ml. of freshly boiled, distilled water at room temperature. To 250 ml. of distilled water in a 500-ml. flask add 1 g. of KI and 10 ml. of HCl (1:1). Cool and add 35 ml. of the standard potassium permanganate solution (0.03 *N*) from a burette. Swirl gently and titrate the liberated iodine with the thiosulfate solution


A
Zinc
Acid
H
B
C
Water Inlet
G
E
Water Outlet
D
F
Hot Plate
J
300 cc. Tall Form
18 mm. Diameter
21 mm.
14 mm.
16 mm.
23 mm.
182 mm.
116 mm.
57 mm.
57 mm.
15 mm.
37 mm.
44 mm.
40 mm.
162 mm.
125 mm.
Diameter 82 mm.
50 mm.

Decomposition Flask, Pulsifer Design.,

FIG. 2.—Apparatus for Determination of Sulfur by the Evolution-Titration Method.

to a light straw color. Add several milliliters of the freshly prepared starch solution and continue the titration to the disappearance of the blue color. Calculate the normality of the thiosulfate solution from the standard permanganate solution.

Standard Potassium Iodate (0.0312 N).—Dissolve 1.12 g. of pure KIO_3, and 12 g. of KI in 1000 ml. of distilled water. To 250 ml. of cold distilled water in a 500-ml. flask, add 10 ml. of HCl (1:1) and then as the flask is gently swirled, add 35 ml. of the iodate solution from a burette. Titrate the liberated iodine with the standard sodium thiosulfate solution (0.03 *N*) to a light straw color, add several milliliters of the freshly prepared starch solution and continue titration to the disappearance of the blue color. Calculate the normality of the iodate solution and adjust the solution so that 1 ml. is equivalent to 0.0005 g. of sulfur.

APPARATUS

19. Figure 2 illustrates the details of the apparatus employed. Hydrogen supplied from the Kipp generator, *A*, is freed from any sulfur by passage through a solution of potassium permanganate (2.5 per cent) contained in a Drechsel bottle, *B*, and sodium hydroxide (30 per cent) held in the Drechsel bottle, *C*. Hydrogen is admitted through a glass stopcock, *E*, to the decomposition flask, *D*. The decomposition flask (Pulsifer's design) is provided with a ground-glass stopper, *E*, a funnel, *G*, and a cooling coil, *F*, with inlet and outlet tubes. An ammoniacal solution of cadmium chloride or some other suitable absorbent is held in a 300-ml. beaker, *J*. The absorption should not be carried on in direct sunlight.

NOTE.—It is advisable to use an all-glass apparatus because the length of time (30 minutes) required for the solution of the alloy gives opportunity for fumes of hydrochloric acid to attack rubber stoppers and rubber hose connections, which always contain sulfur, and thus cause erroneous results.

METHOD

20. Transfer to the decomposition flask 5.00 g. of the alloy ribbon which has been cut into very small pieces or of the wire sample which has been flattened by means of a hammer and cut into small pieces. Pass a stream of hydrogen from the Kipp generator through the apparatus to displace the air. Pour 25 ml. of cadmium chloride solution into the beaker, *J*, and add sufficient water to give a depth of 3 in. of the solution. Stop the hydrogen by closing the control stopcock, *H*, on the Kipp generator. Close the stopcock *E*. Remove the ground-glass tube leading into the funnel, *G*, and introduce **100 ml.** of HCl (sp. gr. 1.19) (see Note) into the decomposition flask through

the funnel. As soon as the acid has been added, replace the ground-glass inlet tube, open the stopcock, *E*, and pass a steady stream of hydrogen through the apparatus during the remainder of the determination. Apply sufficient heat to the decomposition flask to maintain a steady decomposition of the sample. Passage of a stream of cold water through the cooling coil, *F*, of the decomposition flask serves to cool the stopper and to aid in maintaining the strength of the acid in the flask. Thirty minutes of this treatment is ordinarily sufficient to cause complete decomposition. When there is no further action, boil the solution in the decomposition flask for several minutes and continue the stream of hydrogen for 5 minutes longer.

At the end of this time remove the absorption beaker, *J*, close stopcock, *E*, and the control stopcock, *H*, and discontinue heating the decomposition flask. Filter the cadmium chloride solution through an 11-cm. filter paper and wash the precipitate several times with water. Return the paper and precipitate to a 600-ml. beaker, add 300 ml. of cold water and 40 ml. of dilute HCl (1:1) and titrate the liberated hydrogen sulfide with the standard solution of potassium iodate, starch solution being used as an indicator.

Carry a blank through all steps of the process and deduct any sulfur that is found.

NOTE.—There is a question whether concentrated HCl or dilute HCl should be used. This method calls for concentrated HCl. See article by Pulsifer, "A Standard Apparatus for the Determination of Sulfur in Iron and Steel by the Evolution Method" in ***Industrial and Engineering Chemistry***, p. 545, 1918.

21. *Calculation.*—If the potassium iodate solution has been adjusted to 0.0312 *N* and 5 g. of the alloy has been dissolved, then the percentage of sulfur is 0.01 times the number of milliliters of the iodate solution used.

OPTIONAL METHOD

22. For an optional method see the Determination of Sulfur by the Evolution-Titration Method (Routine) in the Standard Methods of Chemical Analysis of Plain Carbon Steel (A.S.T.M. Designation: A 33) of the American Society for Testing Materials.[1] This optional method may be used for Nickel-Chromium and for Nickel-Iron-Chromium Alloys with the following precautions:

1. Due to the length of time (30 minutes) required for solution of the alloy, closer observation is necessary than in the analysis of steel.

2. During the solution of the sample, care must be exercised in order that the absorbing solution is not drawn back into the flask.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 326.

3. There is danger of contamination from rubber hose connections and rubber stoppers.

4. The use of a gas flame is a possible source of sulfur contamination and an electric heater is recommended.

Accuracy.—In the case of a sulfur content of 0.05 per cent, duplicate determinations should check within ±0.003 per cent sulfur.

DETERMINATION OF COPPER

A. Nickel-Copper Alloys Containing 10 to 90 per cent Copper

SOLUTIONS REQUIRED

23. The following reagents will be required:

Dilute Nitric Acid (1:3).—Slowly stir 50 ml. of HNO_3 (sp. gr. 1.42) into 150 ml. of distilled water.

Dilute Sulfuric Acid (1:1).—Slowly stir 10 ml. of concentrated H_2SO_4 (sp. gr. 1.84) into 10 ml. of water.

METHOD

24. Dissolve exactly 2.000 g. of the alloy in 25 ml. of the dilute HNO_3 (sp. gr. 1.135) and when solution is complete, boil to expel nitrous fumes and dilute with about 175 ml. of cold water. Add 5 ml. of the dilute sulfuric acid (1:1).

Determine the copper by electrolysis. Use a current of 0.5 ampere unless the solution is agitated, in which case a larger current up to 4 amperes may be used.

Accuracy.—Duplicate determinations should check within ±0.10 per cent of copper.

NOTE.—A little copper may be retained by the iron precipitate. The presence of molybdenum or silver will cause high results for copper.

B. Copper up to 5 per cent in Alloys of Chromium with Iron or Nickel or Both

SOLUTIONS REQUIRED

25. The following reagents will be required:

Ferric Sulfate.—Dissolve 0.8 g. of ferric sulfate ($Fe_2(SO_4)_3 \cdot 9\,H_2O$) in 100 ml. of distilled water.

Dilute Sulfuric Acid (1:4).—Slowly stir 50 ml. of H_2SO_4 (sp. gr. 1.84) into 200 ml. of distilled water.

Dilute Sulfuric Acid (1:1).—Slowly stir 100 ml. of H_2SO_4 (sp. gr. 1.84) into 100 ml. of distilled water.

Acidified Hydrogen Sulfide Water.—Mix 10 ml. of HCl (sp. gr. 1.19) and 1000 ml. of distilled water and saturate with H_2S.

Ammonium Hydroxide (sp. gr. 0.90).

METHOD

26. Dissolve exactly 5.000 g. of the alloy in a 400-ml. covered beaker in 100 ml. of HCl (sp. gr. 1.19) at about 65° C. When the reaction is complete, dilute to approximately 300 ml. with warm water. Introduce ammonium hydroxide (sp. gr. 0.90) until the solution is practically neutral and then add sufficient HCl (sp. gr. 1.19) to give an acidity of 3 ml. of HCl (sp. gr. 1.19) per 100 ml. of solution. Treat the solution with a brisk stream of hydrogen sulfide for at least 30 minutes.

Filter the precipitate of sulfide on a 9-cm. paper containing a small amount of paper pulp and wash thoroughly with the acidified hydrogen sulfide water. Discard the filtrate.

Return the paper and the precipitate to a 250-ml. covered beaker and treat with 3 ml. of H_2SO_4 (sp. gr. 1.84) and 25 ml. of HNO_3 (sp gr. 1.42) and evaporate slowly to fumes of sulfur trioxide. Add sufficient HNO_3 (sp. gr. 1.42) in small quantities to completely oxidize the filter paper and subsequently heat the solution until strong fumes of sulfur trioxide are evolved and all HNO_3 has been expelled.

Add 25 ml. of the ferric sulfate solution to the cooled sulfuric acid solution and add ammonium hydroxide (sp. gr. 0.90) in small excess. Heat the solution to boiling and after the precipitated ferric hydroxide has settled, filter on a 9-cm. paper and wash with hot water.

Dissolve the precipitate in a small amount of hot dilute H_2SO_4 (1:4) and wash the filter with water. Repeat the ammonia precipitation and the filtration and combine the filtrates. Acidify with an excess of 5 ml. of H_2SO_4 (1:1), add 1 ml. of HNO_3 (sp. gr. 1.42) and evaporate to approximately 100 ml.

Determine the percentage of copper by electrolysis, using a perforated platinum cathode and a spiral anode.

In case a trace of copper is to be determined, start with four 5-g. portions of sample and combine them after the hydrogen sulfide precipitates have been filtered.

Accuracy.—Duplicate determinations should check within ±0.02 per cent copper.

NOTE—A little copper may be retained by the iron precipitate. The presence of molybdenum or silver will cause high results for copper.

DETERMINATION OF ALUMINUM

SOLUTIONS REQUIRED

27. The following reagents will be required:

Nitrohydrochloric Acid.—Mix 10 ml. of HNO_3 (sp. gr. 1.42), 30 ml. of HCl (sp. gr. 1.19) and 40 ml. of water.

Perchloric Acid (60 per cent).

Dilute Hydrochloric Acid (1:19).—Mix 5 ml. of HCl (sp. gr. 1.19) and 95 ml. of water.

Cupferron (6 per cent).—Dissolve the amount of cupferron, $C_6H_5N \cdot NO \cdot ONH_4$, needed in cold water in the ratio of 6 g. to 100 ml. of water, and filter if not clear. This solution must be made fresh as required.

Sulfuric Acid (1:1).—Slowly stir 50 ml. of H_2SO_4 (sp. gr. 1.84) into 50 ml. of water.

Dilute Ammonium Hydroxide (1:1).—Mix 50 ml. of NH_4OH (sp. gr. 0.90) and 50 ml. of water.

Ammonium Chloride (2 per cent).—Dissolve 2 g. of ammonium chloride in 100 ml. of water.

Potassium Pyrosulfate, $K_2S_2O_7$.

Methyl Red (2 per cent).—Dissolve 2 g. of methyl red in 100 ml. of 95 per cent alcohol.

Hydrofluoric Acid (48 per cent).

Dimethylglyoxime Solution (1 per cent).—Dissolve 1 g. of dimethylglyoxime in 65 ml. of NH_4OH (sp. gr. 0.90) and dilute to 100 ml. with cold water.

METHOD

28. (*a*) Dissolve exactly 1 g. of the sample of nickel-aluminum-alloy containing over 1 per cent of aluminum, or 2 g. of the sample of nickel-chromium or nickel-chromium-iron alloy containing less than 1 per cent of aluminum in 20 to 40 ml. of nitrohydrochloric acid in a covered 600-ml. beaker (Note). Add 15 to 25 ml. of perchloric acid (60 per cent) and heat gently until fumes of perchloric acid just begin to be evolved (no longer). This is done in order to expel the nitric acid and to convert as little chromium as possible in the chromium alloys to chromic acid. The amount of HNO_3 remaining and the small amount of chromic acid formed will not interfere with the cupferron precipitation that is to follow. Add 50 ml. of water, boil for several minutes to expel free chlorine and filter on a 9-cm. paper. Wash the filter well with hot water. Collect the filtrate in a 250-ml. beaker and boil down to a volume of about 50 ml.

(*b*) Ignite the paper containing the silica in platinum at a low temperature to burn off the carbon of the paper. Add one or two drops of H_2SO_4 (1:1), about 1 ml. of HF, and evaporate the solution until all of the acid has been expelled. Fuse any residue with 1 or 2 g. of potassium pyrosulfate, $K_2S_2O_7$, and dissolve the melt in dilute HCl (1:1). Add several drops of methyl red solution (2 per cent alcoholic solution) and then add dilute NH_4OH (1:1) cautiously until in very faint excess. Boil for one or two minutes (no longer), filter and wash well with a hot solution of NH_4Cl (2 per cent). Dissolve any precipitate off the filter in 20 ml. of hot HCl (1:1) and wash the paper with hot water. Add this solution to the 250-ml. beaker containing the perchloric acid solution of the alloy. Add 10 ml. of HCl (sp. gr. 1.19) and bring the total volume to 100 ml. either by dilution with cold water or by boiling if the amount exceeds 100 ml. Cool the solution to about 15 C.; treat with a slight excess of a cold freshly prepared solution of cupferron (6 per cent) which should cause the complete precipitation of the iron and any titanium present, while all of the aluminum will remain in solution. A brownish-red, partly amorphous, partly crystalline precipitate separates out. Complete precipitation of the iron can be told by the sudden coagulation of the precipitate and the fact that further addition of cupferron causes the formation of a transient snow-white precipitate which quickly dissolves. Filter on an 11-cm. paper containing some ashless paper pulp and wash the precipitate 18 to 20 times with cold HCl (1:19). Discard the precipitate. Collect the filtrate in a 600-ml. beaker and evaporate to a volume of about 50 ml. Add 25 ml. of HNO_3 (sp. gr. 1.42) and boil slowly until dense fumes of perchloric acid are evolved. If HNO_3 is not added an explosion may result. Continue the boiling for at least five minutes longer to insure the complete destruction of all organic matter and the complete conversion of the chromium to chromic acid. Manganese dioxide may separate at this point but it does no harm. Cool the solution rapidly by placing the beaker in a tray of ice water. Dilute with 100 ml. of cold water and boil for several minutes to expel free chlorine. Add 200 ml. of boiling water and 10 g. of NH_4Cl and then filtered dilute NH_4OH (1:1) slowly and with stirring until a faint odor of ammonia can be detected after rinsing down the sides of the beaker with water. Boil for one or two minutes (no longer), filter and wash well with a hot solution of NH_4Cl (2 per cent). Dissolve the precipitate off the filter with hot HCl (1:1) and wash the filter with water. Boil for one or two minutes, add 5 g. of NH_4Cl and filtered dilute NH_4OH (1:1) in very faint excess. Boil for 1 minute, filter and wash thoroughly with a hot solution of NH_4Cl (2 per cent). The second ammonia precipitation and filtration serve to remove the bulk of the nickel that is precipitated during the first precipitation.

(*c*) Dissolve the precipitate off the paper with hot HCl (1:1) and wash the filter with hot water. Add 10 ml. of perchloric acid (60 per cent) and boil until dense fumes of perchloric acid are evolved. Continue the boiling for 3 to 5 minutes longer to insure the complete conversion of any remaining chromium to chromic acid. Cool the solution rapidly in ice water as previously described. Add 50 ml. of water, boil for several minutes to expel free chlorine and filter to remove any silica. Wash the filter well with hot water. Add 5 g. of NH_4Cl and then filtered dilute NH_4OH (1:1) in very faint excess. Boil for 1 minute, filter and wash eight or ten times with a hot solution of NH_4Cl (2 per cent). Dissolve the precipitate off the paper with hot HCl (1:1) and wash the filter with hot water. Add 2 g. of NH_4Cl and repeat the precipitation with ammonia, filtration, and washing as previously described. Ignite in a weighed platinum crucible first at a low temperature and finally at 1100 to 1150 C. (to constant weight), cool and weigh. While in the desiccator and on the balance pan the crucible should be covered with a tightly-fitting cover. Should the precipitate not be perfectly white, fuse it with a small amount of sodium carbonate and dissolve the melt in water. Add approximately 0.5 g. of sodium peroxide, boil and filter. Test the filtrate colorimetrically for chromium. Convert any chromium found to Cr_2O_3 and deduct from the weight of the impure Al_2O_3 precipitate. Dissolve the residue in HCl and test for nickel with dimethylglyoxime in the usual manner. Convert any nickel found to NiO, and deduct. The weight of Al_2O_3 found, multiplied by 52.94 and divided by the weight of sample taken, gives the percentage of aluminum in the alloy.

(*d*) Run a blank on all of the reagents used and deduct any aluminum found. This method yields results that are correct to within ±0.05 per cent.

NOTE.—The most accurate procedure for the determination of aluminum in these alloys would be to remove the iron, nickel and chromium in mercury by electrolyzing the sulfate solution of the alloy.

DETERMINATION OF TITANIUM

SOLUTIONS REQUIRED

29. The following reagents will be required:

Dilute Hydrochloric Acid (*1:9*).—Mix 10 ml. of HCl (sp. gr. 1.19) and 90 ml. of water.

Dilute Hydrochloric Acid (1:1).—Mix 50 ml. of HCl (sp. gr. 1.19) and 50 ml. of water.

Perchloric Acid (60 per cent).

Ammonium Chloride, C.P.

Ammonium Hydroxide (sp. gr. 0.90).

Dilute Sulfuric Acid (1:1).—Slowly stir 50 ml. of H_2SO_4 (sp. gr. 1.84) into 50 ml. of water.

Dilute Sulfuric Acid (1:9).—Slowly stir 10 ml. of H_2SO_4 (sp. gr. 1.84) into 90 ml. of water.

Dilute Ammonium Hydroxide (1:1).—Mix 50 ml. of NH_4OH (sp. gr. 0.90) and 50 ml. of water.

Hydrofluoric Acid (48 per cent).

Sodium Sulfite, C.P., $Na_2SO_3 . 5H_2O$.

Potassium Pyrosulfate, $K_2S_2O_7$.

Hydrogen Peroxide (3 per cent).

Cupferron (6 per cent).—Dissolve the amount of cupferron, $C_6H_5N \cdot NO \cdot ONH_4$, needed in cold water in the ratio of 6 g. to 100 ml. of water, and filter if not clear. This solution must be made fresh as required.

Sodium Hydroxide Solution (10 per cent).—Dissolve 1 g. of NaOH in 10 ml. of water.

Standard Titanium Sulfate Solution.—One ml. = 0.0005 g. of titanium. Dissolve 2.70 g. of potassium-titanium fluoride, $K_2TiF_6 \cdot H_2O$ (which has been twice recrystallized from hot water in a platinum dish and dried at room temperature), in 75 ml. of H_2SO_4 (1:1) in a large platinum dish and evaporate to dense fumes of sulfur trioxide. Allow to cool, add 25 ml. of water and again evaporate to dense fumes of sulfur trioxide. Add 25 ml. of water and repeat the evaporation to dense fumes of sulfur trioxide to insure the complete removal of every trace of fluorine. Cool, and pour into a beaker containing 900 ml. of H_2SO_4 (1:9). Transfer to a 1-liter volumetric flask, and rinse the beaker and platinum dish with H_2SO_4 (1:9). Cool to room temperature, dilute to the mark with H_2SO_4 (1:9) and mix thoroughly. Standardize by taking 50-ml. portions, diluting with boiling water to 200 ml., precipitating with NH_4OH, boiling and filtering. Dissolve the precipitate in 25 ml. of hot HCl (1:1) and wash the filter thoroughly with hot water. Repeat the precipitation with ammonia, filtration and washing to insure the complete removal of all potassium salts. Ignite the paper and precipitate in platinum, first at a low temperature and finally at 1100 C. Cool and weigh as TiO_2. Each milliliter of the solution should contain 0.0005 g. of titanium. The precipitate of TiO_2 contains 59.95 per cent titanium.

METHOD

30. (*a*) The colorimetric method for titanium is based on the light-straw to amber color developed when hydrogen peroxide is added to a sulfuric acid solution containing titanium; it is limited to solutions containing not more than 0.1 mg. of titanium per milliliter.

(*b*) For alloys containing 1 per cent of titanium, use a ½-g. sample; for those containing 0.50 per cent of titanium, use a 1-g. sample; and for alloys containing 0.25 per cent of titanium and under, use a 2-g. sample. Treat the sample in a 600-ml. covered Pyrex (or equivalent) beaker with 10 to 25 ml. of perchloric acid (60 per cent) at the boiling point of the acid until the alloy has dissolved completely, and continue the boiling for 5 to 10 minutes longer to aid in the complete oxidation of the chromium to the sexivalent state. Chill to about 10 C. by immersing the beaker in cold water, add approximately 100 ml. of hot water, boil and filter to remove the silica. Wash the filter thoroughly with hot water and discard. Add an excess of 5 ml. of NH_4OH (sp. gr. 0.90) to the filtrate and boil for one or two minutes. Filter and wash thoroughly with hot water. Discard the filtrate. Return the paper and precipitate containing the titanium to the beaker. Add 50 ml. of HCl (1:3) and heat for 5 minutes near the boiling point of the acid with frequent stirring to aid in the complete solution of the ferric hydroxide. Add NH_4OH (1:1) until a precipitate just begins to form and then clear with HCl (1:1). Add from 1 to 2 g. of $Na_2SO_3 . 5H_2O$, dissolved in 10 ml. of hot water, and stir the solution thoroughly to insure the reduction of the iron to the ferrous condition. Add 15 ml. of HCl (sp. gr. 1.19) and cool to 15 C. Add dropwise, and with vigorous stirring, from 3 to 5 ml. of a cold, freshly prepared solution of cupferron (6 per cent) and filter on an 11-cm. paper containing some ashless paper pulp. Wash 10 or 12 times with cold HCl (1:9). Transfer the paper and precipitate to a 50-ml. platinum crucible and ignite at a low temperature to insure the complete destruction of the carbon. Should the alloy be known to contain vanadium, fuse the ignited cupferron precipitate with a small amount of potassium pyrosulfate, $K_2S_2O_7$, and dissolve the melt in hot H_2SO_4 (1:9). Add a slight excess of NaOH, boil for one or two minutes and filter. Wash the paper and precipitate thoroughly with hot water. Ignite at a low temperature to burn off the carbon. Fuse with approximately 1 g. (a sufficient amount) of $K_2S_2O_7$ and dissolve the melt in 25 ml. of H_2SO_4 (1:9). Cool and transfer the solution to a Camp or Nessler comparison tube, add 3 ml. of H_2O_2 (3 per cent) and mix thoroughly. A light-straw to amber color, proportional in intensity to the amount of titanium, will be developed.

To a second comparison tube, add the same amount of $K_2S_2O_7$ that was used to make the fusion and which has been dissolved in the cold H_2SO_4 (1:9), 3 ml. of H_2O_2 (3 per cent), and dilute both the sample and the standard with cold H_2SO_4 (1:9) to a volume of 50 ml. From a 10-ml. burette, add a measured amount of the standard titanium sulfate solution to the standard and a similar volume of cold H_2SO_4 (1:9) to the sample until the colors match when the solutions are well mixed. The sample then contains the same amount of titanium as was added to the standard. Each milliliter of the standard titanium solution required, multiplied by 0.0005 and by 100, and divided by the weight of sample taken, gives the percentage of titanium in the alloy.

TENTATIVE METHOD OF TEST
FOR
LINEAR EXPANSION OF METALS[1]

A.S.T.M. Designation: B 95 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1934.

Scope

1. This method is intended especially for determining the expansion of oxidation-resistant alloys at temperatures up to 1000 C.

Apparatus

Dilatometer

2. The dilatometer shall be of the quartz tube type. All parts of the dilatometer proper exposed to heat from the furnace shall be of quartz. A dial gage or equivalent device shall be provided for measuring length changes. The gage shall be sufficiently sensitive to permit length changes of 0.0001 in. to be read directly. Its accuracy shall be such that the error of indication of any length change up to 0.100 in. shall not exceed 0.0001 in. The details of two forms of quartz tube dilatometer that will satisfy the requirements of this method are described in the Appendix.

Note.—Dial gages of the geared type or of the screw-and-lever type have proven effective. A micrometer screw with electrical means for indicating contact with the transmission rod or a microscope with suitable equipment are alternative means.

Micrometer Calipers

3. For 4-in. measurements. The sensitivity shall be such that the index can be read directly to 0.001 in. The accuracy shall be equal to that of high-grade screw micrometers customarily used in machine shop practice.

Electric Furnace

4. An electric-tube furnace in which the temperature throughout the specimen can be maintained within 3 C. at any desired temperature up to 1000 C. will be required.

Note.—The details of a furnace which will provide the required temperature control are shown in Fig. 1.

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys.

Furnace Control

5. Rheostats or other means shall be provided that will enable the power input to the test furnace to be controlled to close limits. It should be possible to alter the power to the furnace by increments of less than 0.5 per cent and the voltage of the power circuit should not be subject to sudden fluctuations.

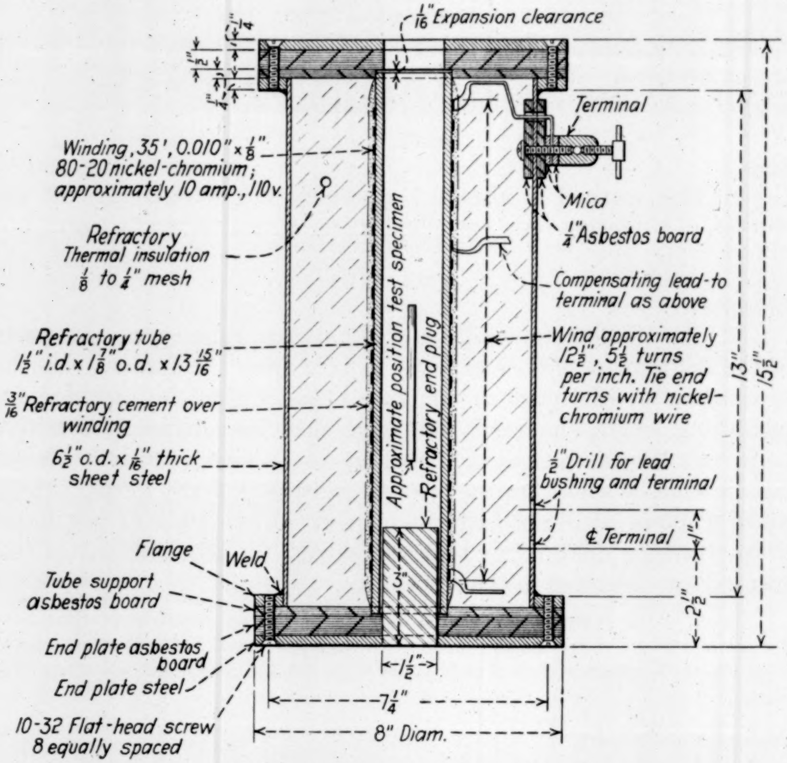

1/16" Expansion clearance
1/4"
1/2"
1/4"
Terminal
Winding, 35', 0.010" × 1/8" 80-20 nickel-chromium; approximately 10 amp., 110 v.
Mica
1/4" Asbestos board
Refractory Thermal insulation 1/8 to 1/4" mesh
Compensating lead-to terminal as above
Approximate position test specimen
Refractory end plug
Refractory tube 1 1/2" i.d. × 1 7/8" o.d. × 13 15/16"
Wind approximately 12 1/2", 5 1/2 turns per inch. Tie end turns with nickel-chromium wire
13"
15 1/2"
3/16" Refractory cement over winding
6 1/2" o.d. × 1/16" thick sheet steel
1/2" Drill for lead bushing and terminal
℄ Terminal
1"
Flange
Weld
Tube support asbestos board
3"
2 1/2"
End plate asbestos board
End plate steel
1 1/2"
7 1/4"
10-32 Flat-head screw 8 equally spaced
8" Diam.

FIG. 1.—Expansion Furnace.

Furnace Power Measuring Instruments

6. A wattmeter or other means shall be provided that will enable the power input to the furnace to be measured with an accuracy of 5 per cent and which is sufficiently sensitive to clearly indicate power changes of 1 per cent.

Temperature Measuring Instruments

7. (*a*) *Thermocouples and Potentiometer.*—During the test the temperatures near the ends and middle of the specimen shall be determined by means of thermocouples with an accuracy of ±5 C. The

sensitivity of the potentiometer or the device used for measuring the temperature shall be such that the temperature differences or temperature changes of 2 C. or more are clearly indicated.

(*b*) *Calibrated Base-Metal or Platinum-Rhodium Thermocouples* and a calibrated high-grade industrial potentiometer may be used. Base-metal couples shall not be used for more than one cycle of heating and cooling at temperatures over 500 C. If platinum couples are used the portions near the specimen shall be cut off after operating for two runs at temperatures over 500 C.

TEST SPECIMEN

Shape and Size of Specimen

8. The test specimen shall be a rod 4 in. ±0.01 in. in length with the ends machined flat and parallel to within 0.0001 in. The measurement of the length shall be made after the thermocouples have been attached, in order to avoid the chance of error in the measurement due to any change caused by the method of attaching the thermocouples. The diameter shall be not less than $\frac{1}{4}$ nor more than $\frac{7}{16}$ in., and shall not vary throughout the length of a specimen more than 0.01 in. The surface shall be free from scratches or other surface irregularities that can interfere with freedom of motion of the specimen in the dilatometer.

PROCEDURE

Preparation for Test

9. *Calibration of Furnace.*—The input-temperature characteristics of the furnace shall first be established. This includes determination and recording of the compensating rheostat settings necessary to secure temperatures uniform within 3 C. throughout the sample, as well as the relation between furnace input and equilibrium temperature for a number of points over the temperature range covered by the contemplated test work. From these data graphs may be plotted that will be of great convenience when predetermined temperature conditions are to be established. The calibration of the furnace shall be done with the dilatometer and specimen set up as for an expansivity determination and the temperature data shall be obtained by means of thermocouples welded or otherwise intimately attached to the specimen near its midpoint and ends. The details of construction of a suitable furnace as well as information as to suitable electrical connections and measuring instruments are shown in the Appendix.

Preparation of Specimen and Assembly of Apparatus

10. The specimen shall be prepared and the apparatus assembled as follows:

(*a*) Attach a thermocouple near each end and at the middle of the specimen by spot welding, brazing, soldering, or other means that will maintain intimate thermal contact between thermocouples and test specimen.

(*b*) Clean the specimen to remove oil, moisture, or other contamination and install it in the dilatometer after having made certain that its end surfaces as well as the contact surfaces of the dilatometer are free of foreign particles. The thermocouple leads shall be so disposed as to preclude their interfering with the operation of the dilatometer and adequately insulated by porcelain beads, capillary tubing or other refractory insulation free of organic matter.

(*c*) Mount the dilatometer tube on its carrier.

(*d*) Put the transmission rod in place.

(*e*) Mount the dial gage or equivalent measuring device and set to appropriate zero reading, gently tapping the dilatometer mounting to make sure that all parts have settled into stable relation.

Test Procedure

11. *Standard Method.*—The test shall be made in accordance with the following procedure:

(*a*) Record dilatometer readings and specimen temperatures with furnace at room temperature.

(*b*) Adjust furnace controls to obtain the first of the chosen test temperatures (Note) and allow furnace to come substantially to equilibrium.

NOTE.—When dealing with materials whose previous thermal history is unknown, it is generally necessary after the apparatus is assembled that the specimen be stabilized as by heating to the maximum temperature to be considered, held for 1 hr. and allowed to cool to room temperature before the actual thermal expansion test is started.

(*c*) Observe in quick succession and record thermocouple readings and time of each observation.

(*d*) Observe and record dilatometer reading and time of observation, gently tapping the dilatometer tube or carrier to eliminate any frictional lag.

(*e*) Again observe in quick succession and record thermocouple readings and time of observation. If the means of the two sets of thermocouple readings differ by more than 3 C., adjust the furnace input or allow further time to permit closer approach to equilibrium and then repeat the observations made as above until the mean temperatures of the specimen measured immediately before and after taking the dilatometer reading differ by less than 3 C.

(*f*) When a satisfactory set of observations has been secured, adjust the furnace controls for the next chosen test temperature and again proceed as outlined in Paragraphs (*b*) to (*e*).

(*g*) Similarly obtained measurements shall be made and recorded for a descending series of temperatures to disclose any lack of reversibility of the dilation characteristic of the specimen and to ascertain the direction and magnitude of any permanent changes in length.

(*h*) As a further check (Paragraph (*g*)), the final length and diameter of the specimen while at a known temperature shall be measured and recorded after removal from the dilatometer at the completion of the test.

(*i*) When occasion requires that the absolute value of the expansivity be known to within $\pm 0.50 \times 10^{-6}$ per deg. Cent., the observed data may be corrected for the expansion of the quartz opposite the test specimen by adding to the observed length changes, 0.54×10^{-6} per deg. Cent.

NOTE.—For correcting observed data, it shall be assumed that, between 0 and 1000 C., quartz has an expansivity of 0.54×10^{-6} per deg. Cent.

12. *Rapid Method.*—In some cases it may be necessary to obtain expansion data at greater rates of temperature change than are possible with the standard procedure described in Section 11. The procedure shall then be as follows:

(*a*) Make the preliminary measurements and adjustments as in the standard method in accordance with Section 11.

(*b*) Apply power to the furnace and adjust from time to time to give the desired heating or cooling rate.

(*c*) Take temperature and dilatometer readings alternately and record together with the times of each of the readings.

(*d*) The final measurement of the specimen shall be performed as specified for the standard method in accordance with Section 11.

(*e*) From these readings plot time-temperature curves for each of the thermocouples and also a time-dilation curve, all referred to a common time zero. By means of these curves the temperatures and the corresponding dilatometer readings can be closely approximated for each of an arbitrarily chosen series of times. These coordinated temperature and dilatation values enable the construction of temperature-dilatation curves of sufficient accuracy for many purposes and are acceptable if the procedure has been previously agreed upon.

REPORT

13. *Identification of Specimen.*—The report shall include the following information concerning the test specimen:

(*a*) Date of test.

(*b*) Designation of material. The chemical analysis is valuable in identifying the material.

(*c*) History of material, especially that relating to thermal or mechanical treatment, whether cast or wrought, etc.

(*d*) Notes as to physical appearance of specimen, straightness, defects, or other observations that may have a bearing on the interpretation of the test data.

(*e*) Remarks as to final physical appearance of sample and conditions of oxidation, warping, cracks, etc., and any other data which may have a bearing on the interpretation of the test data.

14. *Data for Standard Method.*—When the standard method is used, the report shall include the following information:

(*a*) Initial length and diameter of specimen and temperature at which they were measured.

(*b*) Test data at elevated temperatures as follows:

- (*1*) Observed temperatures.
- (*2*) Corresponding dilatometer readings.
- (*3*) Corresponding observed length changes referred to the original length of the specimen as datum.
- (*4*) Corrections to be applied to (*3*) to compensate for the dilation of that portion of the dilatometer tube opposite the test specimen.

15. *Data for Rapid Method.*—When the rapid method is used, the report shall include the following information:

(*a*) Test data at room temperature as follows:

- (*1*) Length of specimen;
- (*2*) Diameter of specimen.

(*b*) Test data at elevated temperatures, in the form of tables or graphs, as follows:

- (*1*) Observed temperatures;
- (*2*) Times of observation;
- (*3*) Corresponding dilatometer readings;
- (*4*) Times of dilatometer observations;
- (*5*) Time-temperature and time-expansion curves;
- (*6*) Table showing:
  - (*a*) Arbitrarily chosen temperatures in test range;
  - (*b*) Dilatometer readings corresponding in time to temperatures of (*a*);
  - (*c*) Length changes derived from (*b*) referred to original length of specimen as datum;
  - (*d*) Corrections for expansivity of dilatometer as described under Section 16.

APPENDIX

The dilatometer consists of a tube of fused quartz (Fig. A1) closed at one end so as to provide a curved end-surface convex inward with which the lower end of the test specimen makes contact. Lateral support for the specimen is provided by indenting the wall of the quartz tube at four points within the length occupied by the specimen by means of the straight edge so as to form two pairs of internal ridges at right angles to the axis of the tube. The inner crests of the upper and lower ridges define a plane nearly parallel to the axis of the tube and lying between the indented side of the tube and the axis and distant from the latter by approximately the radius of the test specimen. The other pair of indentations similarly define a plane at right angles to the first. The specimen while under test rests on these ridges with its lower end in contact with the convex bottom of the dilatometer tube and is thus held in a perfectly definite and reproducible manner with respect to the length and axis of the dilatometer tube while subject to the minimum of constraint.

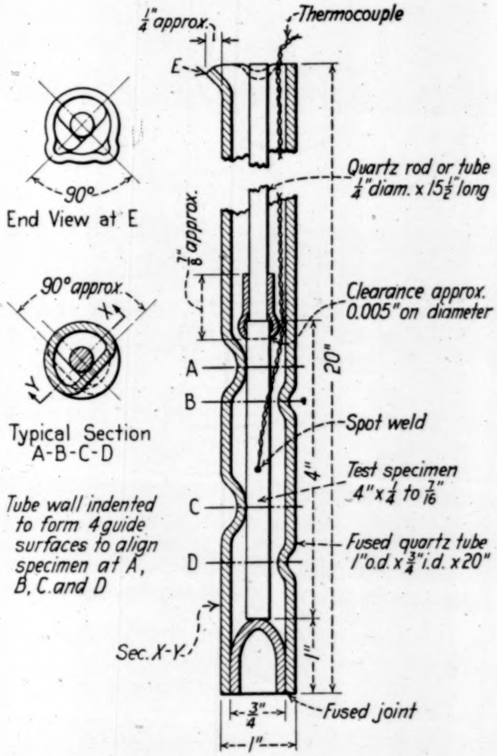

1/4" approx.
Thermocouple
E
90°
End View at E
Quartz rod or tube 1/4" diam. x 15 1/2" long
7/8" approx.
90° approx.
X
Y
Clearance approx. 0.005" on diameter
20"
A
B
Typical Section A-B-C-D
Spot weld
Test specimen 4" x 1/4 to 7/16"
4"
Tube wall indented to form 4 guide surfaces to align specimen at A, B, C and D
C
D
Fused quartz tube 1" o.d. x 3/4" i.d. x 20"
Sec. X-Y
1"
3/4"
1"
Fused joint

FIG. A1.—Specimen for Expansion Test and Comparison Parts.

Two projections are formed at the upper end of the dilatometer tube by sharply flaring the edge outward locally in two axial planes approximately perpendicular to the respective planes of the pairs of indentations. These projections form fiduciary points that locate the dilatometer tube with reference to a supporting member and the dilatation gage.

The motion of the upper end of the test specimen is transmitted to the gage by means of a fused quartz rod whose lower end is convex and is provided with a collar or three short prongs to center the "transmission rod" with respect to the axis of the specimen. Similar means may be used to connect the transmission rod to the contact pin of the gage.

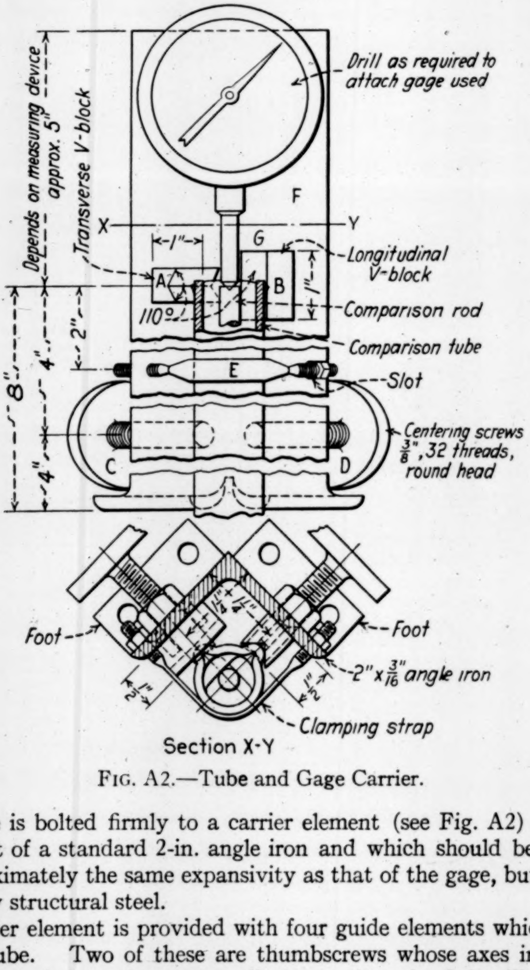

Drill as required to attach gage used
F
X
Y
G
-1"-
Longitudinal V-block
A
B
1"
Comparison rod
110°
Comparison tube
E
Slot
Centering screws $\frac{3}{8}$", 32 threads, round head
C
D
Depends on measuring device approx. 5"
Transverse V-block
2"
4"
8"
4"
Foot
Foot
$1\frac{1}{4}$"
2" x $\frac{3}{16}$" angle iron
$\frac{1}{2}$"
$\frac{1}{2}$"
Clamping strap
Section X-Y

FIG. A2.—Tube and Gage Carrier.

The gage is bolted firmly to a carrier element (see Fig. A2) whose cross-section is that of a standard 2-in. angle iron and which should be of material having approximately the same expansivity as that of the gage, but can usually be of ordinary structural steel.

The carrier element is provided with four guide elements which locate the dilatometer tube. Two of these are thumbscrews whose axes intersect near the dilatometer axis in a plane perpendicular to the axis of the dilatometer and whose slightly concave end surfaces form movable supports that enable centering and aligning of the dilatometer tube. The other two guiding elements are "V" blocks fastened to the inside faces of the angle section opposite one another

4 in. above the centering screws. The grooves of the V blocks engage the fiduciary projections at the top of the dilatometer tube. The axis of one of the V grooves is parallel to the dilatometer axis and provides transverse and rotational constraint. The other V groove lies in a plane perpendicular to the dilatometer axis and provides axial constraint as well as lateral constraint in directions at right angles to that provided by the other V block. A thin metal strap with threaded terminals is provided to hold the dilatometer in contact with the four guide elements. This set-up locates the dilatometer in a fixed and reproducible manner with respect to a definite plane passing through the transverse V block and so causes all axial changes to be referred to this guide block. The length of the transmission rod is so adjusted that its upper end lies in or near the plane perpendicular to the dilatometer axis and passing through the apex of the transverse V groove. Thus the expansion of the carrier member between this plane and the parallel plane passing through the point of attachment of the dial gage is compensated by the nearly equal and oppositely directed expansion of the gage between its point of attachment and the lower end of the gage contact pin.

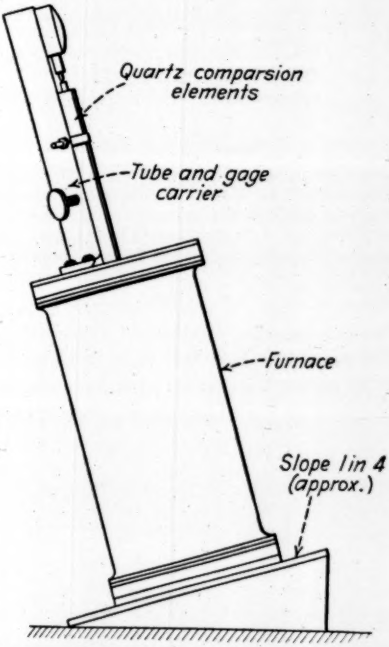


FIG. A3.—General Assembly of Expansion Test Apparatus.

Figure A3 shows an assembly of the furnace and dilatometer parts mounted on an inclined base so that the test specimen is held by gravity against the guiding indentations in the dilatometer tube while at the same time being free of any appreciable bending stresses that would tend to cause plastic flexure at the higher temperatures.

Attachment of the dilatometer carrier to the upper head of the furnace gives a very satisfactory assembly, but requires that this end of the furnace be provided with good thermal insulation and that heat flow to and along the carrier be obstructed as much as possible as by placing insulation under the attachment lugs and cutting holes or transverse slots in the webs of the carrier to reduce the effective cross-section offered to the flow of heat.

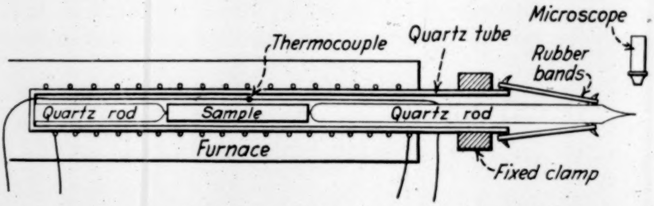


FIG. A4.—Type of Assembly for Use With Microscope.

Quartz Tube, 11 in.
Specimen, 2 in. long by 0.120 in. Diameter, Planed Ends.
α of Quartz, 0.00000054.
Quartz Rods and Tube Compensate Each Other.
Correction Made for 2-in. Quartz Tube at Specimen.

In Fig. A4 is shown a type of assembly that is intended for use with a microscope as a means of measuring dilatation. This representation is diagrammatic only and if this scheme is followed care shall be taken to provide such details of support for the cooperating parts as will ensure the required sensitivity and accuracy.

TENTATIVE METHOD OF TEST
FOR
COMPRESSIVE STRENGTH OF PORTLAND-CEMENT MORTARS[1]

A.S.T.M. Designation: C 109 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

APPARATUS

Scales

1. (*a*) The scales used in weighing materials for mortar mixes shall conform to the following requirements: On scales in use the tolerance at a load of 1500 g. shall be ± 1.0 g. The tolerance on new scales shall be one-half of this value. The "sensibility reciprocal"[2] shall not be greater than twice the tolerance.

(*b*) The tolerances on the weights in use in weighing materials for mortar mixes shall be as follows:

WEIGHT	TOLERANCE	WEIGHT	TOLERANCE
1000 g.	±0.5 g.	100 g.	±0.15 g.
900 g.	±0.45 g.	50 g.	±0.10 g.
750 g.	±0.4 g.	20 g.	±0.05 g.
500 g.	±0.35 g.	10 g.	±0.04 g.
300 g.	±0.3 g.	5 g.	±0.03 g.
250 g.	±0.25 g.	2 g.	±0.02 g.
200 g.	±0.20 g.	1 g.	±0.01 g.

The tolerances on new weights shall be one-half these values.

Glass Graduates

2. Glass graduates of 250-ml. capacities used for measuring the mixing water shall have the main graduation lines completely encircling the cylinder and the intermediate lines at least half-way around the cylinder and shall be made to deliver the indicated volume at 20 C. (68 F.). The tolerance on these graduates shall be ±2.0 ml.

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee C-1 on Cement.

[2] The sensibility reciprocal is a measure of the sensitivity of a balance, and is the weight required to move the position of equilibrium of the beam, pan, pointer, or other indicating device of a scale a definite amount at the capacity or at any lesser load. For a complete definition of sensibility reciprocal, see National Bureau of Standards *Handbook, M 85*, pp. 80–82.

Molds

3. Molds for the 2-in. cube test specimen shall be water-tight and made of hard, non-corroding metal. New molds shall have a hardness of not less than B55 Rockwell number (Brinell number 95). There shall be sufficient material in the sides of the molds to prevent spreading or warping. Two opposite faces shall be true plane surfaces within a tolerance of 0.001 in. for new molds or 0.002 in. for molds in use. The other two faces may depart from a plane surface not more than 0.005 in. provided they are marked by a slight undercut at the center of the face. The area of the mold faces shall be 4.00 ± 0.02 sq. in. The angle between the planes of adjacent faces shall be 90 deg. ± $\frac{1}{2}$ deg.

Testing Machine

4. (*a*) The testing machine for determination of the compressive strength may be either the hydraulic or the screw-type with sufficient opening between the upper bearing surface and the lower bearing surface of the machine to permit the use of verifying apparatus. The load applied to the test specimen shall be indicated with an accuracy of ± 1.0 per cent.

(*b*) The upper bearing shall be a spherically seated, hardened, metal block firmly attached at the center of the upper head of the machine. The center of the sphere shall lie at the center of the surface of the block in contact with the specimen. The block shall be closely held in its spherical seat, but shall be free to turn in any direction. The diagonal or diameter[1] of the bearing surface shall be only slightly greater than the diagonal of the face of the 2-in. cube in order to facilitate accurate centering of the specimen. A hardened metal bearing block shall be used beneath the specimen to minimize wear of the lower platen of the machine. The bearing block surfaces intended for contact with the specimen should have a hardness not less than C60 Rockwell number (Brinell number 620). These surfaces shall not depart from plane surfaces by more than 0.0005 in. when the blocks are new and shall be maintained within a tolerance of 0.001 in.

TEMPERATURE AND HUMIDITY

Temperature and Humidity

5. The temperature of the room and dry materials shall be maintained at not less than 20 C. (68 F.) and not more than 27.5 C. (81.5 F.). The temperature of the mixing water, moist closet, and water in the

---

[1] A diameter of 3$\frac{1}{8}$ in. is satisfactory and is large enough for testing 3 by 6-in. cylinders.

storage tank shall not vary from 21 C. (70 F.) more than 1.7 C. (3 F.). The moist closet or moist room shall be so constructed as to provide storage facilities for test specimens at a relative humidity of not less than 90 per cent.

PREPARATION OF SPECIMENS

Graded Ottawa Sand

6. The sand (Note 1) to be used shall be natural silica sand produced by the Ottawa Silica Co., Ottawa, Ill., graded as follows:

Retained on No. 100 sieve	98 ± 2 per cent
Retained on No. 50 sieve	72 ± 5 per cent
Retained on No. 30 sieve	2 ± 2 per cent
Retained on No. 16 sieve	0 per cent

Sieve Analysis of Sand

7. (*a*) Samples for sieve analyses shall be quartered from a sample of about 700 g. obtained by the method of quartering the contents of a full sack (100 lb.) which have been thoroughly mixed and the pile flattened or spread out to minimize segregation during quartering.

(*b*) The fineness test shall be made with 100 g. of sand. The sieve shall be thoroughly clean and dry. The sand shall be placed on the sieve, with pan and cover attached, and shall be held in one hand in a slightly inclined position so that the sample will be well distributed over the sieve, at the same time gently striking the side about 150 times per minute against the palm of the other hand on the up stroke. The sieve shall be turned every 25 strokes about one-sixth of a revolution in the same direction. The operation shall be continued until not more than 0.5 g. passes through in 1 min. of continuous sieving. The fineness shall be determined from the weight of the residue on the sieve expressed as a percentage of the weight of the original sample.

Sieve Requirements

8. The Nos. 100, 50, 30 and 16 sieves shall conform to the requirements for these sieves as specified in the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[1]

Preparing Molds

9. Molds shall be thinly covered with mineral oil. The clamped faces shall be thinly covered with a heavy mineral oil or light cup grease. After assembling the mold, excess oil or grease shall be wiped

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

from the joints. Molds shall be set on a plane, non-absorbent base plate which has been thinly coated with paraffin or mineral oil. A mixture of 3 parts paraffin to 5 parts resin by weight heated to between 110 and 120 C. (230 and 248 F.) shall be applied at the outside contact line of the mold and base plate so that a water-tight bond is effected between mold and base (Note 2).

Proportioning and Mixing of Mortars

10. (*a*) The mortar shall consist of 1 part cement to 2.77 parts graded Ottawa sand by weight and 53 per cent water by weight of cement (water-cement ratio of 0.8 by volume).

(*b*) Mixing shall be done in a bowl (graniteware or other non-absorbent, non-corroding material) of about 1-gal. capacity by vigorous and continuous stirring, squeezing and kneading with one hand which shall be protected by a snug-fitting rubber glove. The materials shall be introduced in the following manner:

(*1*) Measure 250 ml. of water into the bowl, which has previously been wiped with a damp cloth.
(*2*) Add 470 g. of cement to the water, and mix for 30 sec.
(*3*) Add approximately one-half of the 1300 g. of graded Ottawa sand, and mix for 30 sec.
(*4*) Add the remaining sand, and mix for 1½ min.

Molding Specimens

11. Immediately following completion of mixing, the molds shall be filled about half full with the mortar and the mortar puddled with the finger tips, protected with snug-fitting rubber gloves (Note 5). Then the molds shall be filled with the mortar and the operation of puddling with the finger tips repeated. The tops of the cubes shall then be troweled just enough to secure a smooth surface flush with the top of the mold.

Storage of Test Specimens

12. Immediately after molding, the specimens shall be placed in the moist closet or moist room with their upper surfaces exposed to the moist air but protected from dripping water. Specimens shall remain in the molds for at least 20 hr.; if removed from the molds before 24 hr., they shall be kept on shelves of the moist closet or moist room until expiration of the 24-hr. period. When 24 hr. old, the specimens shall be immersed in clean water in storage tanks constructed of non-corroding materials. The storage water shall be kept clean by frequent changing.

Testing of Cubes

13. Testing shall be carried out immediately after removal of the cubes from the moist closet for 24-hr. specimens, and from storage water for all other tests. The load shall be applied to the faces of the cube that were in contact with the true plane surfaces of the mold. These faces shall be checked by application of an accurate straight edge (Note 3). If appreciable curvature is present, the face or faces shall be ground to a plane surface before loading, or the specimen shall be discarded.

14. The cube shall be carefully placed in the testing machine below the center of the upper bearing block. No cushioning or bedding materials shall be used. An initial load of not more than 50 per cent (25 per cent for low-heat portland cements at ages of 7 days or less) of the expected maximum load shall be applied at any convenient rate, after which the specimen shall be loaded continuously to failure at a rate or rates which shall at no time be less than 1000 nor more than 6000 lb. per sq. in. per min.[1]

Calculation of Strength

15. The total maximum load indicated by the testing machine shall be recorded, and the compressive strength calculated in pounds per square inch from the cross-sectional area of the cube tested (Note 4). Cubes that are manifestly faulty or that give strengths differing more than 10 per cent from the average value of all test specimens made from the same sample and tested at the same period shall not be considered in determining the compressive strength (Note 5).

EXPLANATORY NOTES

NOTE 1.—*Segregation of Graded Sand:* The graded Ottawa sand should be handled in such a manner as to prevent segregation, since variations in the grading of the sand cause variations in the consistency of the mortar. It is recommended that each sack of sand be emptied when delivered to the laboratory for use and its contents mixed by means of a shovel or scoop. The sand may then be resacked if desired and scooped directly from the sack as needed in testing. In both of these operations care should be taken to prevent segregation. In emptying sacks of sand into bins or in scooping it out of bins, care should be exercised to prevent the formation of mounds of sand or craters in the sand, down the slopes of which the coarser particles will roll. Bins should be of sufficient size to permit the above precautions. Devices for drawing the sand from bins by gravity should not be used.

---

[1] While the data presented in the report of the 1933 cooperative tests (see the Report of Working Committee on Plastic Mortar Tests for Portland Cement, of Committee C-1 on Cement, p. 322, do not give conclusive evidence on effect of rate of loading, the Working Committee favors the use of a uniform rate of loading of about 4000 lb. per sq. in. per min. (1000 lb. per sq. in. per min. for low-heat portland cements at ages of 7 days or less).

NOTE 2.—*Water-tight Molds:* The mixture of paraffin and resin specified for sealing the joint between mold and base plate may be found difficult to remove when molds are being cleaned. A water-tight joint may be secured with paraffin alone by slightly warming the mold and base plate before brushing the joint. Molds so treated should be allowed to return to room temperature before use. Use of straight paraffin is permissible *if a water-tight joint is secured.*

NOTE 3.—*Cube Faces:* Results much lower than the true strength will be obtained by loading faces of the cube which are not truly plane surfaces. Therefore, it is essential that cube molds be kept scrupulously clean, as otherwise large irregularities in the surfaces will occur. Instruments for cleaning of molds should always be softer than the metal in the molds to prevent wear. In case grinding of cube faces is necessary, it can be accomplished best by rubbing the cube on a sheet of fine emery paper or cloth glued to a plane surface, using only a moderate pressure. Such grinding is tedious for more than a few thousandths of an inch; where more than this is found necessary, it is recommended that the cube be discarded.

NOTE 4.—*Calculation of Strength:* Ordinarily, the cross-sectional area of the cube tested may be assumed to be 4.00 sq. in.; however, in cases where the area of the cube varies more than 0.06 sq. in. from 4.00 sq. in., the actual area shall be used for calculation of the compressive strength.

NOTE 5.—*Faulty Cubes:* Faulty cubes may result from occlusions of air during molding unless care is exercised. All indentations resulting from the puddling of the lower layer of mortar should be smoothed out before introducing the top layer. Excess puddling, resulting in segregation of the materials, should be avoided. In testing, cubes should be loaded to destruction and after rupture their centers examined for air pockets. Improper centering of cubes resulting in oblique fractures or lateral movement of one of the heads of the machine during loading will often cause lower strength results. Cubes so broken shall be considered as "manifestly faulty" unless their strengths agree within reasonable limits with those of cubes exhibiting a normal pyramidal fracture.

TENTATIVE SPECIFICATIONS

FOR

QUICKLIME FOR STRUCTURAL PURPOSES[1]

A.S.T.M. Designation: C 5 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover all classes of quicklime, such as, crushed lime, granular lime, ground lime, lump lime, pebble lime and pulverized lime, when used for structural purposes.

Chemical Composition

2. All classes of quicklime shall conform to the following requirements as to chemical composition, calculated to the non-volatile basis:

	CALCIUM LIME	MAGNESIUM LIME
Calcium oxide, min., per cent	75	..
Magnesium oxide, min., per cent	..	20
Calcium and magnesium oxides, min., per cent	95	95
Silica, alumina, and oxide of iron, max., per cent	5	5
Carbon dioxide, max., per cent:		
If sample is taken at the point of manufacture	3	3
If sample is taken at any other place	10	10

Residue

3. Quicklime shall contain not more than 15 per cent by weight of residue.

Soundness

4. Quicklime for use in the scratch, brown or finish coats of plaster shall pass the test for soundness. If the steam has no visible effect on the specimen, the sample shall be reported as being "sound."

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-7 on Lime.

These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Quicklime for Structural Purposes (A.S.T.M. Designation: C 5 – 26), 1933 Book of A.S.T.M. Standards, Part II, p. 24.

If the specimen either disintegrates or pops, the sample shall be reported as being "unsound," and the shipment shall be rejected.

Sampling, Retesting, Packing, Marking

5. The sampling, retesting, packing and marking shall be conducted in accordance with the Standard Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (A.S.T.M. Designation: C 50) of the American Society for Testing Materials.[1]

Methods of Testing

6. The properties enumerated in these specifications shall be determined in accordance with the following methods of the American Society for Testing Materials:

(*a*) *Chemical Analysis.*—Standard Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (A.S.T.M. Designation: C 25).[2]

(*b*) *Physical Tests.*—Tentative Methods of Physical Test for Limestone, Quicklime and Hydrated Lime (A.S.T.M. Designation: C 110 - 34 T).[3]

APPENDIX

Quicklime can never be used as such for structural purposes; it must always be slaked first. Since the method of slaking is an important factor in determining the quality of the finished product, the following directions are given, not as a part of the specifications, but as information for the further protection of the purchaser.

PREPARATION OF LIME PUTTY

A1. *Introduction.*—Different kinds of lime vary considerably in the way in which they behave with water. A little supervision over the operation of slaking will amply pay for itself by insuring the production of the greatest possible quantity and the best possible quality of putty. To find out how to slake a new lot of lime, it is safest to try a little of it and see how it works. Since different lots of the same brand of lime vary somewhat, and since the weather conditions at the time have a decided influence, it is wise to try a sample from each lot used, whether familiar with the brand or not.

A2. *Classification of Limes.*—In a bucket, put two or three lumps of lime about the size of one's fist, or, in the case of granular lime, an equivalent amount. Add sufficient water to just barely cover the lime, and note how long it takes for slaking to begin. Slaking has begun when pieces split off from the lumps or when the lumps crumble. Water of the same temperature should be used for test and field practice.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 66.

[2] *Ibid.*, p. 49.

[3] See p. 754.

If slaking begins in less than 5 min., the lime is quick slaking; from 5 to 30 min., medium slaking; over 30 min., slow slaking.

A3. *Directions for Slaking.*—For quick-slaking lime, always add the lime to the water, not the water to the lime. Have sufficient water at first to cover all the lime completely. Have a plentiful supply of water available for immediate use—a hose throwing a good stream, if possible. Watch the lime constantly. At the slightest appearance of escaping steam, hoe thoroughly and quickly, and add enough water to stop the steaming. Do not be afraid of using too much water with this kind of lime.

For medium-slaking lime, add the water to the lime. Add enough water so that the lime is about half submerged. Hoe occasionally if steam starts to escape. Add a little water now and then if necessary to prevent the putty from becoming dry and crumbly. Be careful not to add any more water than required, and not too much at a time.

For slow-slaking lime, add enough water to the lime to moisten it thoroughly. Let it stand until the reaction has started. Cautiously add more water, a little at a time, taking care that the mass is not cooled by the fresh water. Do not hoe until the slaking is practically complete. If the weather is very cold, it is preferable to use hot water, but if this is not available, the mortar box may be covered in some way to keep the heat in.

A4. *Preparation of Putty for Use.*—After slaking, the putty shall be prepared for use, as follows:

(*a*) *White Coat.*—After the action has ceased, run off the putty through a No. 10 sieve and store for a minimum of two weeks.

(*b*) *Base Coats.*—After the action has ceased, run off the putty through a No. 8 sieve. Add sand up to equal parts by weight, all of the hair required, and store for a minimum of two weeks.

(*c*) *Masons' Mortar.*—After the action has ceased, add part or all of the sand required, and store for a minimum of 24 hr.

TENTATIVE SPECIFICATIONS
FOR
HYDRATED LIME FOR STRUCTURAL PURPOSES[1]

A.S.T.M. Designation: C 6 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover two classes of hydrated lime: namely,

Masons' Hydrate
Finishing Hydrate

Uses

2. (*a*) *Masons' Hydrate.*—Masons' hydrated lime may be used for scratch or brown coat of plaster, for stucco, for mortar, and for addition to portland-cement concrete.

(*b*) *Finishing Hydrate.*—Finishing hydrated lime may be used for any of the purposes enumerated in Paragraph (*a*) for masons' hydrated lime, and in addition, it may be used as an ingredient in the final or white coat of plaster.

Chemical Composition

3. Hydrated lime shall conform to the following requirements as to chemical composition, calculated to the non-volatile basis:

	Masons' Hydrated Lime	Finishing Hydrated Lime
Calcium and magnesium oxides, min., per cent	95	95
Carbon dioxide, max., per cent:		
If sample is taken at the point of manufacture	5	5
If sample is taken at any other place	7	7

Residue

4. The percentage residue of both classes of hydrated lime shall conform to the following requirements:

Residue retained on No. 30 sieve........not more than 0.5 per cent
Residue retained on No. 200 sieve........not more than 15 per cent

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-7 on Lime.

These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Hydrated Lime for Structural Purposes (A.S.T.M. Designation: C 6 - 31), 1933 Book of A.S.T.M. Standards, Part II, p. 27.

Soundness

5. Both classes of hydrated lime shall pass the test for soundness. If the steam has no visible effect on the specimen, the sample shall be reported as being "sound." If the specimen either disintegrates or pops, the sample shall be reported as being "unsound," and the shipment shall be rejected.

Plasticity

6. Finishing hydrated lime shall have a plasticity figure of not less than 200.

Sampling, Retesting, Packing, Marking

7. The sampling, retesting, packing and marking shall be conducted in accordance with the Standard Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (A.S.T.M. Designation: C 50) of the American Society for Testing Materials.[1]

Methods of Testing

8. The properties enumerated in these specifications shall be determined in accordance with the following methods of the American Society for Testing Materials:

(*a*) *Chemical Analysis.*—Standard Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (A.S.T.M. Designation: C 25).[2]

(*b*) *Physical Tests.*—Tentative Methods of Physical Test for Limestone, Quicklime and Hydrated Lime (A.S.T.M. Designation: C 110 – 34 T).[3]

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 66.

[2] *Ibid.*, p. 49.

[3] See p. 754.

TENTATIVE METHODS OF PHYSICAL TEST
FOR
LIMESTONE, QUICKLIME AND HYDRATED LIME[1]

A.S.T.M. Designation: C 110 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

RESIDUE

Apparatus

1. The sieves used shall conform to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[2]

Residue of Quicklime

2. A representative 2½-kg. (5-lb.) sample of the quicklime shall be selected. Lime selected for this test shall be broken so as to entirely pass a 1-in. ring and be retained on a ¼-in. sieve. Pulverized lime shall be tested as received. The sample shall be placed in a box of wood or of some material of similarly low thermal conductivity and slaked by an experienced operator with sufficient water at 70 to 80 F. (21 to 27 C.) to produce the maximum quantity of lime putty, care being taken to avoid "burning" or "drowning" the lime. It shall be allowed to stand for 1 hr. and then washed through a No. 20 sieve by a stream of water having a moderate pressure. No material shall be rubbed through the sieve. The washing shall be continued until the residue on the screen appears to consist entirely of coarse particles, but in no case shall the washing be continued for more than 30 min. The residue shall be dried to constant weight at a temperature of 212 to 225 F. (100 to 107 C.) and the percentage residue calculated, based on the original weight of the sample.

Residue of Hydrated Lime

3. A 100-g. sample of the hydrated lime as received shall be selected and placed on a No. 30 sieve, which shall be nested above a

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee C-7 on Lime.

These Tentative Methods, when adopted as standard, will be added to the present Standard Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (A.S.T.M. Designation: C 25 - 29), see 1933 Book of A.S.T.M. Standards, Part II, p. 49.

[2] **1933 Book of A.S.T.M. Standards, Part II, p. 1244.**

No. 200 sieve. The material shall be washed through the sieves by means of a stream of water from a faucet. A piece of rubber tubing attached to the water faucet shall be used for the washing. The velocity of the water may be increased by pinching the tubing, but shall not be sufficient to cause any splashing of the sample over the sides of the sieve. The washing shall be continued until the water coming through the sieve is clear, but in no case shall the washing be continued for more than 30 min. Care shall be taken not to let water accumulate on the No. 200 sieve, because the openings will become clogged and the operation cannot be completed in 30 min. The residues on both sieves shall be dried to constant weight in an atmosphere free from carbon dioxide at a temperature between 212 and 248 F. (100 and 120 C.). The percentage residue retained on each sieve shall be calculated, based on the original weight of the sample. The weight of the material retained on the No. 30 sieve shall be added to the weight of the material retained on the No. 200 sieve to obtain the correct weight of the material retained on the No. 200 sieve.

SOUNDNESS

NOTE.—Unsoundness is usually manifested by popping of the specimen.

This method for the determination of soundness was developed originally to test hydrated lime, but it may be equally applicable to quicklime provided a properly prepared lime putty is used.

Preparation of Lime Putty

4. (*a*) *Quicklime.*—Because of the variable slaking characteristics of different quicklimes, it is necessary to determine by preliminary experiment the amount of water required to hydrate the lime at or near the boiling point of the water and produce a fairly stiff putty. It is essential that sufficient water be used to prevent burning of the lime and the possible production of a dry hydrate, as these unfavorable slaking conditions may, in themselves, cause an otherwise potentially sound quicklime to test unsound.

A 200-g. sample of quicklime shall be slaked with the entire amount of water and in the manner previously determined to produce the desired stiffness of putty. The sample shall be stirred to insure even distribution of the water, thus avoiding local heating. The putty shall then be aged in a covered vessel at room temperature for not less than 16 nor more than 24 hr.

(*b*) *Hydrated Lime.*—To a 100-g. sample of hydrated lime, sufficient water shall be added to make a fairly stiff putty. This putty shall be aged in a covered vessel at room temperature for not less than 16 nor more than 24 hr.

Soundness Test Procedure

5. (*a*) Two or three volumes of the aged putty prepared from either quicklime or hydrated lime in accordance with Section 4 (*a*) or (*b*) shall be thoroughly mixed with one volume of unretarded calcined gypsum (Note) and sufficient water to form a paste. A layer of this gaged paste of from $\frac{1}{16}$ to $\frac{1}{8}$ in. in uniform thickness shall be spread on a 4 by 4-in. glass plate and the specimen set aside for an hour or two, thus allowing the gypsum to set.

NOTE.—The calcined gypsum shall be previously tested to assure soundness by steaming a duplicate specimen of the neat gypsum for 2 hr. in an autoclave at a pressure of 120 lb. per sq. in.

(*b*) The specimen shall then be placed on a rack in an autoclave to which water has been added equal to 1 to 2 per cent of its volume. The rack shall be provided with a cover that will prevent water from dripping onto the specimen. The steam pressure shall then be raised to 120 lb. per sq. in. and maintained for 2 hr., after which it shall be released through a valve at such a rate that atmospheric pressure is reached in about 5 min. The autoclave shall then be opened and the specimen examined.

STANDARD CONSISTENCY OF LIME PUTTY

Apparatus

6. (*a*) *Modified Vicat Apparatus*.—The modified Vicat apparatus shown in Fig. 1 shall be used. This consists of a bracket, *A*, bearing a movable brass rod, *B*, 6.3 mm. in diameter and of suitable length to fit the Vicat bracket. On the lower end of the rod is attached a plunger, *C*, 12.5 mm. in diameter, made of aluminum tubing. The total weight of the rod with plunger shall be 30 g. The lower end of the plunger shall be closed without shoulders or curvature and the tube may be loaded with shot to the specified weight. The total weight required may also be obtained by means of a weight, *D*, screwed into the rod. The rod can be held in any position by means of a screw, *E*, and has a mark midway between the ends which moves under a scale, *F*, graduated in millimeters, attached to the bracket, *A*.

(*b*) *Mold*.—The conical ring mold shall be made of a non-corroding, non-absorbent material, and shall have an inside diameter of 7 cm. at the base, 6 cm. at the top and a height of 4 cm.

(*c*) *Base Plate*.—The base plate for supporting the ring mold shall be of plate glass and about 10 cm. square.

Standard Consistency Determination

7. (*a*) *Procedure*.—Standard consistency of lime putty shall be measured as follows: About 300 g. of hydrated lime shall be mixed

with sufficient water to form a thick putty and stirred with a trowel or spatula for 2 or 3 min. to insure intimate mixing. After aging in a vessel covered with a damp cloth for not less than 16 nor more than 24 hr., this putty shall again be stirred for 2 or 3 min. and a sufficient quantity placed in the ring mold resting on the glass base plate. The mold shall be placed with its larger end resting on the base plate and after filling, the lime putty shall be struck off flush with the top of the mold. The lime putty, confined in the ring mold, resting on the plate, shall then be centered under the rod of the modified Vicat apparatus, Fig. 1. The plunger end, *C*, shall then be brought in contact with the surface of the lime putty and an initial reading taken. The rod shall then be released and the final reading shall be taken 30 sec. after the plunger is released.

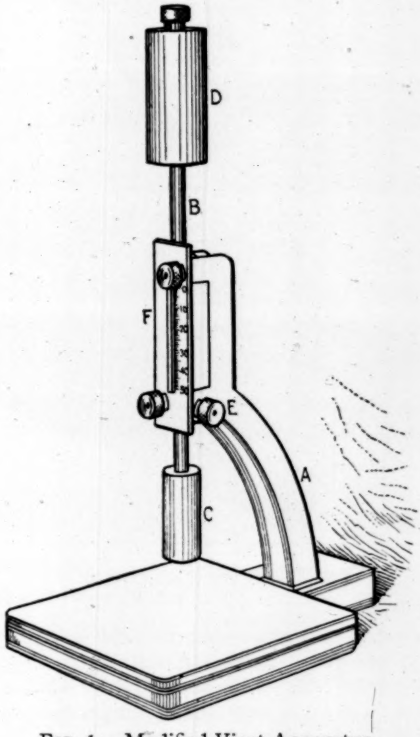


FIG. 1.—Modified Vicat Apparatus.

(*b*) *Standard Consistency.*—The lime putty shall be of standard consistency when a penetration of 20 mm. is obtained in 30 sec. A permissible variation of ±5 mm. is allowed in preparing the sample for the plasticity determination described in Section 8.

(*c*) If the penetration is less than standard, the sample may be removed from the mold, combined with the original aged putty, the whole mixed with more water, stirred for 2 or 3 min., and a suitable quantity retested. If the penetration is more than standard, the sample shall be discarded and a new one prepared.

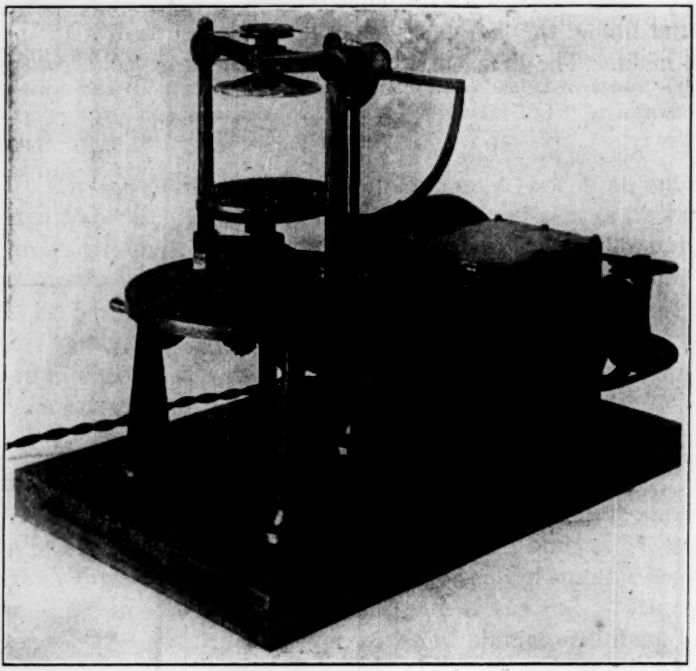


FIG. 2.—Emley Plasticimeter.

Constants of the Machine:

Absorption of porcelain base plate.—Minimum of 40 g. in 24 hr. For rate of absorption of base plates, see Section 11.

Dimension of base plate.—1 in. in thickness by 4 in. in diameter.

Dimensions of disk.— $\frac{1}{32}$ in. in thickness by 3 in. in diameter.

Speed of vertical shaft.—One revolution in 6 min., 40 sec.

Upward movement of base plate.— $\frac{1}{13}$ in. per revolution.

Torque on disk when bob reading is 100.—14,400 g.c.m.

PLASTICITY OF LIME PUTTY

Plasticity Determination

8. (*a*) Plasticity of lime putty shall be determined by means of the apparatus shown in Fig. 2 as follows: A ring mold such as is described in Section 6 (*c*) shall be lubricated with a thin film of water, placed on a porcelain base plate (see Sections 10 and 11), filled with

the paste which has been adjusted to standard consistency as described in Section 7, and struck off level. The mold shall be removed by raising it vertically without distorting the paste. The base plate and paste shall be centered in the instrument and the carriage turned up by hand until the surface of the paste is in contact with the disk and the distance between the disk and the top of the base plate is 32 mm. ($1\frac{1}{4}$ in.). The carriage shall then be thrown into gear and the motor started. It is essential that the motor shall be started exactly 120 sec. after the first portion of the paste has been placed in the mold. The time when the first portion of paste is placed in the mold shall be recorded as zero time—the motor is therefore started at 2 min. Care shall be taken to protect the specimen from drafts during the test.

(*b*) The scale reading shall be recorded every minute until the test is completed. The test shall be considered complete when (*1*) the scale reading reaches 100; (*2*) any reading is less than the one before; or (*3*) the scale reading remains constant for three consecutive readings (2 min.) and the specimen has visibly ruptured or broken loose from the base plate. The time and the scale reading at the end of the test shall be noted.

Calculation

9. The plasticity figure shall be calculated from the following formula:

$$P = F^2 + (10T)^2$$

where P = the plasticity figure;
F = the scale reading at the end of the test; and
T = the time in minutes from when the first portion of paste was put in the mold to the end of the test.

Cleaning and Care of Base Plates

10. In making plasticity determinations much of the success attainable depends upon the condition of the base plates. Continued use of the plates without proper cleaning results in clogging of the pores, with reduction in the rate of absorption. After a plate has been used the excess lime shall be wiped off and the plate immersed in clear water for not less than 2 hr., after which it shall be transferred without drying to a dilute solution of HCl (1:9) where it shall be kept immersed for another 2 hr. It shall then be transferred to a receptacle containing running water for at least 1 hr. The plate is then free of acid and, after the removal of excess water, shall be placed in an oven overnight at a temperature of between 212 and 230 F. (100 and 110 C.) for drying. Before using, the plate shall be cooled to room temperature.

Absorption of Plasticimeter Base Plates

11. (*a*) *Total Absorption.*—Plasticimeter base plates when immersed in water at room temperature for a period of 24 hr. shall absorb not less than 40 g. of water. Before making the determination the plates shall be dried overnight in an oven at a temperature of between 212 and 230 F. (100 and 110 C.) and permitted to cool to room temperature. After immersion and before weighing, the excess water shall be wiped off with a damp cloth.

(*b*) *Rate of Absorption.*[1]—When tested over an area 2¾ in. in diameter the water absorbed shall be in accordance with the following:

	WATER ABSORBED, ML.
First minute	8 to 14
Second minute	5 to 7½
Third minute	4 to 6½
Fourth minute	4 to 6
Fifth minute	3½ to 5½

---

[1] A convenient apparatus for determining the rate of absorption consists of a burette sealed onto an inverted glass funnel from which the stem has been removed. The diameter of the larger end of the funnel shall be ground so as to be 2¾ in. in internal diameter. The funnel may be attached to the plate on which the measurement is being made by melted paraffin. The paraffin should not be too hot. A little experience will indicate when it is of the proper consistency.

TENTATIVE SPECIFICATIONS
FOR
STRUCTURAL CLAY FLOOR TILE[1]

A.S.T.M. Designation: C 57 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1924; ADOPTED IN AMENDED FORM, 1927; REVISED, 1930, 1931; REISSUED AS TENTATIVE, 1933; REVISED, 1934.[2]

Scope

1. These specifications apply to structural clay floor tile made from surface clay, shale, fire clay or admixtures thereof.

CLASSIFICATION

Classification

2. (*a*) According to the results of physical tests, tile to be used in flat or segmental arches or used to resist stresses in combination tile and concrete ribbed slab construction, shall be classified as 5–16 and 16–25 on the basis of the following strength and absorption requirements:

Class	Absorption, per cent			Compressive Strength Based on Net Area,[a] lb. per sq. in.			
				End-Construction Tile		Side-Construction Tile	
	Average of 5 Tests	Individual Maximum	Individual Minimum	Average of 5 Tests	Individual Minimum	Average of 5 Tests	Individual Minimum
5-16...........	5 to 16	19	4	3200 or more	2250	1600 or more	1100
16-25...........	25 or less	28	4	2000 or more	1400	1200 or more	850

[a] Net area of a unit shall be taken as the area of solid material in shells and webs actually carrying stresses in a direction parallel to direction of loading.

(*b*) Where end-construction tile are used on the side they shall conform to the requirements of that construction, and *vice versa*.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-10 on Hollow Masonry Building Units.

These specifications are in effect a revision of, and replace the former Standard Specifications and Tests for Structural Clay Floor Tile (A.S.T.M. Designation: C 57 - 31), which standard was accordingly discontinued in 1934.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

WEIGHTS

Weights

3. (*a*) Flat and segmental arch tile shall conform to the following requirements as to minimum number of cells in arch thickness and average dry weights per square foot of tile:

FLAT ARCH TILE

DEPTH OF ARCH, IN.	MINIMUM NUMBER OF CELLS IN ARCH THICKNESS	AVERAGE DRY WEIGHT, LB. PER SQ. FT. OF TILE
6	1	26
7	1	30
8	2	32
9	2	33
10	2	35
11	2	38
12	2	40
13	2	43
14	3	46
15	3	47
16	3	52
SEGMENTAL ARCH TILE		
6	2	30
8	2	36

(*b*) A tolerance of 5 per cent under and 12.5 per cent over will be allowed on the average dry weights specified in Paragraph (*a*).

(*c*) Tile designed to resist stresses in combination tile and concrete ribbed slab construction shall conform to the following requirements as to minimum number of cells in thickness and average dry weights per square foot of tile:

THICKNESS OF UNITS, IN.	MINIMUM NUMBER CELLS IN THICKNESS OF TILE	AVERAGE DRY WEIGHTS, LB. PER SQ. FT. OF TILE
3	1	15
4	1	16
5	1	19
5	2	23
6	1	22
6	2	25
7	1	24
7	2	27
8	1	27
8	2	29
9	2	31
9	3	36
10	2	33
10	3	38
12	2	40
12	3	45

(*d*) A tolerance of ± 10 per cent will be allowed on the average weights per square foot specified in Paragraph (*c*).

(*e*) Structural clay floor tile units may be made any size consistent with economic considerations of manufacturing and practicable engineering standards of design.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions

4. No dimension shall vary more than ± 3 per cent from the standard dimensions for any form of tile.

COLOR AND WORKMANSHIP AND FINISH

Color

5. Color of tile varies with the type of clay used and degree of burning; hence, it cannot be taken as indicative of classification until after it has been related to absorption and strength by actual tests.

Workmanship

6. All tile shall be reasonably free from laminations and from such cracks, blisters, surface roughness and other defects as would interfere with the proper setting of the tile or impair the strength or permanence of the construction.

Scoring

7. The exterior surface of all tile intended for plaster shall be scratched or scored. When scored, each groove shall be not less than $\frac{1}{8}$ in. nor more than $\frac{3}{16}$ in. in depth, nor more than 1 in. in width. The area covered by the grooves shall not exceed 50 per cent of the area of the scored faces.

MARKING

Marking

8. All tile shall bear the initials, name or trademark of the manufacturer. These marks shall be indented on the exterior of the tile and shall be plainly legible.

INSPECTION AND REJECTION

Inspection

9. Proper facilities shall be provided the purchaser for sampling and inspection either at the factory or at the site of the work, as may be specified. At least 10 days from the time of sampling shall be allowed for the completion of the test. The inspection shall be based on the requirements specified in Sections 2 to 8, inclusive. All tests shall be made in accordance with the methods specified in Section 12.

Rejection

10. (*a*) Individual tile shall be rejected for failure to meet the weight, size, or workmanship and finish requirements. In case of failure to meet the absorption and strength requirements for the class specified, the manufacturer may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the manufacturer. In case the second set of samples fails to meet the test requirements the entire lot shall be rejected.

Acceptance

(*b*) By agreement, acceptance may be based on dry weight of the units, percentage of absorption, and the workmanship and finish.

Expense of Tests

11. Except as specified in Section 10 and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser.

METHODS OF TESTING

Methods of Testing

12. Tile shall be sampled and tested in accordance with the Tentative Methods of Sampling and Testing Structural Clay Tile (A.S.T.M. Designation: C 112 – 34 T) of the American Society for Testing Materials.[1]

---

[1] See p. 776.

TENTATIVE SPECIFICATIONS

FOR

STRUCTURAL CLAY NON-LOAD-BEARING TILE[1]

A.S.T.M. Designation: C 56 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued as Tentative, 1924; Adopted in Amended Form, 1930; Revised, 1931; Reissued as Tentative, 1933; Revised, 1934.[2]

Scope

1. These specifications apply to structural clay partition, fireproofing and furring tile made from surface clay, shale, fire clay or admixtures thereof.

Classification

Classification

2. According to results of physical tests, tile shall be classified as 5–16 and 16–25 on the basis of the following absorption requirements:

Class	Absorption, per cent		
	Average of Five Tests	Individual Maximum	Individual Minimum
5–16	5 to 16	19	4
16–25	16 to 25	28	4

Weights

Weights

3. Partition and split-furring tile shall conform to the following requirements as to minimum number of cells and dry weights per square foot of tile:

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-10 on Hollow Masonry Building Units.

These specifications are in effect a revision of, and replace the former Standard Specifications and Tests for Structural Clay Fireproofing, Partition and Furring Tile (A.S.T.M. Designation: C 56 – 31), which standard was accordingly discontinued in 1934.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

PARTITION TILE

DIMENSIONS, IN.	MINIMUM NUMBER CELLS IN UNIT	MINIMUM NUMBER CELLS IN WALL THICKNESS	MINIMUM AVERAGE WEIGHT, LB. PER SQ. FT. OF TILE	MAXIMUM AVERAGE WEIGHT, LB. PER SQ. FT. OF TILE	INDIVIDUAL MINIMUM WEIGHT, LB. PER SQ. FT. OF TILE
2 by 12 by 12	3	1	14	16	13
3 by 12 by 12	3	1	15	17	14
4 by 12 by 12	3	1	16	18	15
6 by 12 by 12	3	1	22	25	21
6 by 12 by 12	4	2	25	28	24
8 by 12 by 12	4	2	30	34	28
10 by 12 by 12	4	2	35	40	33
12 by 12 by 12	4	2	40	45	38
SPLIT FURRING TILE					
1½ by 12 by 12	3	..	7½	8½	7
2 by 12 by 12	3	..	8	9	7½

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions

4. No dimension shall vary more than ± 3 per cent from the specified dimensions for any form of tile.

COLOR AND WORKMANSHIP AND FINISH

Color

5. Color of tile varies with the type of clay used and degree of burning; hence, it cannot be taken as indicative of classification until after it has been related to absorption and strength by actual tests.

Workmanship

6. All tile shall be reasonably free from laminations and from such cracks, blisters, surface roughness and other defects as would interfere with the proper setting of the tile or impair the strength or permanence of the construction.

Scoring

7. The exterior surface of all tile intended for plaster or stucco shall be scratched or scored. When scored, each groove shall be not less than $\frac{1}{8}$ in. nor more than $\frac{3}{16}$ in. in depth, nor more than 1 in. in width. The area covered by the grooves shall not exceed 50 per cent of the area of the scored faces.

MARKING

Marking

8. All tile shall bear the initials, name or trademark of the manufacturer. These marks shall be indented on the exterior of the tile and shall be plainly legible.

INSPECTION AND REJECTION

Inspection

9. Proper facilities shall be provided the purchaser for sampling and inspection either at the factory or at the site of the work, as may be specified in the contract. At least 10 days from the time of sampling shall be allowed for the completion of the test. The inspection shall be based on the requirements specified in Sections 2 to 8, inclusive. All tests shall be made in accordance with the methods specified in Section 12.

Rejection

10. (*a*) Individual tile shall be rejected for failure to meet the weight, size, or workmanship and finish requirements. In case of failure to meet the absorption requirements for the class specified, the manufacturer may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the manufacturer. In case the second set of samples fails to meet the test requirements, the entire lot shall be rejected.

Acceptance

(*b*) By agreement, acceptance may be based on dry weight of the units, percentage of absorption, and the workmanship and finish.

Expense of Tests

11. Except as specified in Section 10, and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser.

METHODS OF TESTING

Methods of Testing

12. Tile shall be sampled and tested in accordance with the Tentative Methods of Sampling and Testing Structural Clay Tile (A.S.T.M. Designation: C 112 - 34 T) of the American Society for Testing Materials.[1]

---

[1] See p. 776.

TENTATIVE SPECIFICATIONS
FOR
STRUCTURAL CLAY LOAD-BEARING WALL TILE[1]

A.S.T.M. Designation: C 34 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1921; ADOPTED IN AMENDED FORM, 1926;
REVISED, 1927, 1930, 1931; REISSUED AS TENTATIVE, 1933;
REVISED, 1934.[2]

Scope

1. These specifications apply to structural clay load-bearing wall tile made from surface clay, shale, fire clay or admixtures thereof.

CLASSIFICATION

Classification

2. (*a*) According to results of physical tests, tile shall be classified as 5–16 and 16–25 on the basis of the following strength and absorption requirements:

Class	Absorption, per cent			Compressive Strength Based on Gross Area,[a] lb. per sq. in.			
	Average of 5 Tests	Individual Maximum	Individual Minimum	End-Construction Tile		Side-Construction Tile	
				Average of 5 Tests	Individual Minimum	Average of 5 Tests	Individual Minimum
5–16	5 to 16	19	4	1400 or more	1000	700 or more	500
16–25	25 or less	28	4	1000 or more	700	700 or more	500

[a] Gross area of a unit shall be the total area of a section including cells perpendicular to the direction of loading. Re-entrant spaces are included in the gross area, unless these spaces are to be occupied in masonry by portions of adjacent units.

(*b*) Where end-construction tile are used on the side they shall conform to the requirements of that construction, and *vice versa*.

(*c*) All tile shall be so designed that substantially the same masonry strength will be developed in all wall thicknesses for which they are to be used.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-10 on Hollow Masonry Building Units.

These specifications are in effect a revision of, and replace the former Standard Specifications and Tests for Structural Clay Load-Bearing Wall Tile (A.S.T.M. Designation: C 34 - 31), which standard was accordingly discontinued in 1934.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

(*d*) Bonding tile shall be so designed as to provide recesses for header brick courses when laid up in brick-faced walls.

WEIGHTS AND NUMBER OF CELLS[a] IN WALL THICKNESS

Weights and Number of Cells

3. (*a*) Load-bearing tile shall conform to the following requirements as to minimum number of cells[a] in wall thickness and dry weights per square foot of tile:

NOMINAL HORIZONTAL THICKNESS OF TILE AS LAID IN WALL, IN.	MINIMUM NUMBER OF CELLS IN WALL THICKNESS	MINIMUM AVERAGE WEIGHT, LB. PER SQ. FT. OF TILE	MAXIMUM AVERAGE WEIGHT, LB. PER SQ. FT. OF TILE	INDIVIDUAL MINIMUM WEIGHT, LB. PER SQ. FT. OF TILE
4	1	20	23	19
6	2	30	35	28
8	2	36	41	34
10	2	42	48	40
12	3	52	60	49

---

[a] Hollow spaces enclosed within the perimeter of the exterior shells and having a minimum dimension of not less than ½ in. and a cross-sectional area of not less than 1 sq. in.

(*b*) The weight of bonding tile, including complementary shapes, shall be governed by the requirements specified in Paragraph (*a*) and shall be calculated from the average weight of the one or more units required between header brick courses. In calculating area of tile, the greatest vertical face dimension shall be used.

(*c*) In double-shell tile the two voids between exterior and interior shells on either side of the tile shall be considered as one cell in thickness of wall when their combined width is not less than ½ in., provided the short webs between the inner and outer shells are not greater in number or thickness than the long transverse webs holding the inner shells.

(*d*) Re-entrant spaces not less than 1 in. in depth and not less than 1 sq. in. in area, which form cells when the units are laid up in the wall, shall be considered as cells in wall thickness, but not in the units.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions

4. (*a*) The thickness of bonding and other types of tile manufactured for use in combination with brick or other materials may vary from the nominal thicknesses specified in Section 3, as required by construction requirements, but no dimensions shall vary more than ± 3 per cent from the purchasers' or manufacturers' specified dimensions.

(*b*) The average over-all thickness of the shells measured between the inner and extreme outer surfaces of end-construction load-bearing tile shall be at least $\frac{3}{4}$ in., except in double-shell tile the combined average over-all thickness of the inner and outer shell shall be not less than $\frac{3}{4}$ in. The minimum thickness of the webs shall be not less than $\frac{1}{2}$ in.

(*c*) The width of cells in side-construction tile, measured in the direction of wall thickness, shall not exceed five times the average over-all thickness of either the upper or lower bearing shells.

WEATHERING RESISTANCE

Weathering Resistance

5. All tile which will be subjected to weathering conditions or intended to be stuccoed shall be able to withstand 100 alternate freezings and thawings. Tile classed as 5–16 by these specifications may be considered as meeting the weathering requirements, provided they are burned to a normal maturity for the given clay. Tile classed as 16–25 shall be accepted as meeting the weathering requirements only on the basis of freezing-and-thawing tests.

COLOR AND WORKMANSHIP AND FINISH

Color

6. Color of tile varies with the type of clay used and degree of burning; hence, it cannot be taken as indicative of classification until after it has been related to absorption and strength by actual tests.

Workmanship

7. All tile shall be reasonably free from laminations and from such cracks, blisters, surface roughness, and other defects as would interfere with the proper setting of the tile or impair the strength or permanence of the construction.

Scoring

8. The exterior surface of all tile intended for plaster or stucco shall be scratched or scored. When scored, each groove shall be not less than $\frac{1}{8}$ in. nor more than $\frac{1}{4}$ in. in depth, nor more than 1 in. in width. The area covered by the grooves shall not exceed 50 per cent of the area of the scored faces.

MARKING

Marking

9. All load-bearing tile shall bear the word "Load-Bearing" or "L-B," and name, initials or trademark of the manufacturer. These marks shall be indented on the exterior of the tile and shall be plainly legible.

INSPECTION AND REJECTION

Inspection

10. Proper facilities shall be provided the purchaser for sampling and inspection either at the factory or at the site of the work, as may be specified. At least 10 days from the time of sampling shall be allowed for the completion of the test. The inspection shall be based on the requirements specified in Sections 2 to 9, inclusive. All tests shall be made in accordance with the methods specified in Section 13.

Rejection

11. Individual tile shall be rejected for failure to meet the weight, number of cells, specified size, or workmanship and finish requirements. In case of failure to meet the absorption and strength requirements for the class specified, the manufacturer may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the manufacturer. In case the second set of samples fails to meet the test requirements the entire lot shall be rejected.

Expense of Tests

12. Except as specified in Section 11 and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser.

METHODS OF TESTING

Methods of Testing

13. Tile shall be sampled and tested in accordance with the Tentative Methods of Sampling and Testing Structural Clay Tile (A.S.T.M. Designation: C 112 - 34 T) of the American Society for Testing Materials.[1]

---

[1] See p. 776.

TENTATIVE SPECIFICATIONS AND TESTS FOR LOAD-BEARING CONCRETE MASONRY UNITS[1]

A.S.T.M. Designation: C 90 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1931; REVISED, 1933, 1934.[2]

SPECIFICATIONS

Scope.

1. These specifications apply to strength, absorption and general requirements of hollow load-bearing concrete masonry wall units made from portland cement and suitable aggregates such as sand, gravel, crushed stone, bituminous or anthracite cinders, burned clay or shale, and blast-furnace slag.[3]

COMPRESSIVE STRENGTH

Compressive Strength.

2. The average compressive strength of five units at the time of delivery to the site shall be not less than the following:

	Compressive Strength Based on Gross Area, lb. per sq. in.	
Minimum Face Shell Thickness, in.	Mean of Five Tests	Individual Minimum
1¼ or over	700	600
Under 1¼ and over ¾	1000	800

ABSORPTION

Absorption.

3. (*a*) Concrete masonry units which will be exposed to the weather or soil in the finished work (without brick, stucco or other suitable protective covering approved by the purchaser) shall not absorb more than 15 lb. of water per cubic foot of concrete actually contained.

(*b*) Units which will be suitably protected from the weather or soil in the finished work need not conform to the absorption requirement specified in Paragraph (*a*).

(*c*) The average percentage of moisture in the units at time of delivery shall not exceed 40 per cent of the total absorption of the units when calculated as described in Section 25 (*b*).

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-10 on Hollow Masonry Building Units.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

[3] When fire tests are required they shall be conducted in accordance with the Standard Specifications for Fire Tests of Building Construction and Materials (A.S.T.M. Designation: C 19), see 1933 Book of A.S.T.M. Standards, Part II, p. 254.

DIMENSIONS AND PERMISSIBLE VARIATIONS

4. No dimension shall vary more than 3 per cent over or under the specified dimension for any form or size of unit. **Dimensions.**

WORKMANSHIP AND FINISH

5. (*a*) All units shall be sound and free from cracks or other defects as would interfere with the proper placing of the unit or impair the strength or permanence of the construction. **Workmanship and Finish.**

(*b*) Units which are intended to serve as a base for plaster or stucco shall have a sufficiently rough surface to give good bond.

MARKING

6. All units shall bear a distinctive mark of the manufacturer or shall otherwise be readily identified as to origin. **Marking.**

INSPECTION AND REJECTION

7. Proper facilities shall be provided the purchaser for sampling and inspection either at the factory or at the site of the work, as may be specified in the contract. The inspection shall be based on the requirements specified above. At least ten days from the time of sampling shall be allowed for the completion of tests. All tests shall be made in accordance with the methods specified in Sections 10 to 25. **Inspection.**

8. Individual units shall be rejected for failure to meet size or workmanship and finish requirements. In case of failure to meet the strength and/or absorption requirements, the manufacturer may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the manufacturer. In case the second set of samples fails to meet the test requirements the entire lot shall be rejected. **Rejection.**

9. Except as specified in Section 8 and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser. **Expense of Tests.**

METHODS OF TESTING

SAMPLING

10. Samples of units for testing shall be selected and tested by the purchaser or by a competent representative authorized by him to do this work. In all cases the samples shall be representative of the whole lot of units from which they are selected. Full-size units shall be taken in all cases. **Selection of Samples for Test.**

11. For the strength and absorption determinations, ten individual units shall be selected from each lot of 10,000 units or fraction thereof; 20 individual units from each lot of more than 10,000 and less than 100,000 units. For lots of more than 100,000 units ten indi- **Number of Samples.**

vidual units shall be selected from each 50,000 units contained in the lot. Where the absorption determination is not required the number of units taken may be reduced by half.

Time and Place of Selecting Samples. 12. Samples for the strength and absorption tests shall be selected at the factory or at the site of the work, as specified.

Marking Samples. 13. All units selected for purpose of tests shall be permanently identified and accurately weighed before shipment to laboratory.

COMPRESSIVE STRENGTH TESTS

Samples. 14. Five full-size units shall be used. The units shall be in an air-dry condition equivalent to that obtained by a period of seven days' protection from the weather at room temperature at from 60 to 80° F.

Speed of Testing Machine. 15. The speed of the moving head of the testing machine shall be not more than 0.05 in. per minute.

Bearing Block. 16. A spherical bearing block of proper design shall be placed on top of the test specimen. When the bearing area of the spherical bearing block is not sufficient to cover the area of the specimen, metal plates of sufficient thickness to prevent appreciable bending shall be placed between the spherical bearing block and the specimen.

Capping. 17. (*a*) Bearing surfaces of the test specimens and portions adjoining them which are liable to absorb water from the plastic capping shall be coated with shellac and allowed to dry.

(*b*) A quantity of plastic mortar made of a mixture of one part (by volume) of portland cement and one part of unretarded gypsum (plaster of Paris) mixed with sufficient water to spread evenly shall be placed on a plain surface which has been coated with oil. The surface to be capped shall be placed on this mortar, and while holding the specimen so that its axis is at right angles to the capping surface it shall be given a single firm pressure.

(*c*) The average thickness of the cap after the extruded plaster has been removed and the edges trued shall be not more than $\frac{1}{8}$ in. Patching of caps after setting shall not be permitted. Imperfect caps shall be removed and replaced with new ones.

Time of Testing. (*d*) The cap shall age at least six hours before the unit is tested.

(*e*) When the specimens are made with irregular bearing surfaces, a 1:2 portland-cement mortar may be used to provide plane surfaces prior to capping.

Position of Unit. 18. All units shall be tested in a position such that the load is applied in the same direction as in service.

Calculation. 19. The compressive strength of a unit shall be the maximum load applied divided by the gross cross-sectional area in square inches.

ABSORPTION TESTS

Selection of Test Samples. 20. The samples shall consist of five whole units or pieces from each one of five units. If pieces are used they shall weigh not less than one-third the weight of the whole unit from which they were taken and in no case less than 5 lb. The samples shall have had any loose particles removed and any rough or jagged edges ground smooth.

When pieces are used as above, the dry weight of the unit shall be calculated by multiplying the weight of the undried unit by the ratio the dry weight of the piece bears to the same piece before drying.

Marking Test Samples. 21. Each piece shall be marked so that it may be identified at any time with the unit from which it was taken. Markings which do not cover more than 5 per cent of the total superficial area of the piece shall be used.

Drying Test Samples. 22. Preparatory to the absorption tests, all samples shall be dried in a drier or oven at a temperature between 100 and 115° C. (212 and 239° F.) and weighed at 24-hour intervals until the loss in weight does not exceed 1 per cent of the last previous weight.

Accuracy of Weighings. 23. The balance used shall be accurate to within 0.5 per cent of the weight of the smallest unit or piece tested.

Saturation of Samples. 24. The dry weight of the samples shall be obtained after which they shall be immersed completely in water at room temperature at from 15.6 to 26.7° C. (60 to 80° F.) for 24 hours. The samples shall then be weighed while suspended with a metal wire and completely submerged in water. They shall be removed from the water and allowed to drain for 60 seconds by placing on $\frac{3}{8}$-in. or coarser wire mesh, visible surface water being removed with a damp cloth, and immediately weighed.

Calculations. 25. (*a*) *Absorption.*—The absorption in pounds per cubic foot is equal to 62.4 times the difference between the wet and dry weights divided by the difference between the wet and suspended immersion weights, as follows:

$$\text{Absorption, lb. per cu. ft.} = \frac{(\text{Wet Weight} - \text{Dry Weight}) \times 62.4}{\text{Wet Weight} - \text{Suspended Immersion Weight}}$$

(*b*) *Percentage of Moisture in Units as Delivered.*—The percentage of moisture in the units as delivered is the difference between the weight of the units when sampled and the dry weight, divided by the dry weight and multiplied by 100.

(*c*) *Total Absorption.*—The total absorption referred to in Section 3 (*c*) is the difference between the wet and dry weight of the unit divided by the dry weight and multiplied by 100.

TENTATIVE METHODS OF SAMPLING AND TESTING STRUCTURAL CLAY TILE[1]

A.S.T.M. Designation: C 112 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

SAMPLING

Selection of Test Specimens

1. Specimens of tile for purpose of tests shall be selected by the purchaser or by a competent representative authorized by him to do this work. In all cases the specimens shall be representative of the whole lot of tile from which they are selected. Full-size tile shall be taken in all cases.

Number of Specimens

2. For the weight, strength and/or absorption determinations, a total of at least five individual tile specimens shall be selected from each kiln or from each 100-ton lot. In no case shall less than five tile be taken. If specimens are required for the freezing-and-thawing tests, they shall be taken from tile that have not been subjected to strength tests.

Time and Place of Selecting Specimens

3. Specimens of tile for purpose of tests shall be selected at the factory or at the site of the work, as specified. If the freezing-and-thawing tests are to be made it shall be so specified at the time of placing the order, specimens being selected at the factory 90 days in advance of the time of filling the order.

Identification

4. All specimens selected for purpose of tests shall be plainly and permanently marked for reference by the testing operator.

WEIGHT DETERMINATIONS

Test Specimens

5. Five full-size tile specimens shall be tested.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee C-10 on Hollow Masonry Building Units.

These methods were formerly published with the Standard Specifications for Structural Clay Tile (C 34, C 56 and C 57) and were issued separately in 1934 under the present designation.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

Weight Determinations

6. The five tile specimens, if not in kiln-dry condition, shall be dried to constant weight at a temperature of not less than 100 C. (212 F.) and shall then be weighed separately.

Accuracy of Weighings

7. The balance used shall be sensitive to within 0.5 per cent of the weight of the smallest specimen tested.

COMPRESSIVE STRENGTH TESTS

Test Specimens

8. Five dry full-size tile specimens shall be tested.

Capping Test Specimens

9. (*a*) Bearing surfaces of the test specimens and portions adjoining them which are liable to absorb water from the plastic capping shall be coated with shellac and allowed to dry. A quantity of plastic mortar made of a mixture of three parts (by volume) of portland cement and one part of unretarded gypsum (plaster of Paris) mixed with sufficient water to spread evenly shall be placed on a plain surface which has been coated with oil. The surface to be capped shall be placed on this mortar, and while holding the specimen so that its axis is at right angles to the capping surface it shall be given a single firm pressure.

(*b*) The average thickness of the cap after the extruded plaster has been removed and the edges trued shall not be more than $\frac{1}{8}$ in. Patching of caps after setting shall not be permitted. Imperfect caps shall be removed and replaced with new ones.

(*c*) Cement-gypsum capping shall be aged at least 3 days before the specimens are tested. If the tests must be made sooner, the specimens may be capped with a neat mortar of unretarded gypsum. Gypsum caps shall be aged at least 1 hr. before the specimens are tested. If the specimens tested with gypsum caps fail to meet the strength requirements, other specimens from the same lot shall be tested with the cement-gypsum caps aged at least 3 days.

Procedure

10. (*a*) *Position of Specimens.*—All specimens shall be tested in a position such that the load is applied in the same direction as in service.

(*b*) *Bearing Block.*—A spherical bearing block of proper design shall be placed on top of the test specimen.

(*c*) *Speed of Testing.*—The speed of the moving head of the testing machine shall not be more than 0.05 in. per min.

Calculating and Reporting Results

11. (*a*) The compressive strength of load-bearing wall tile shall be taken as the maximum load in pounds divided by the gross cross-sectional area of the tile in square inches. The gross area of a tile is the total area of a section perpendicular to the direction of the load, including areas within cells and within re-entrant spaces unless these spaces are to be occupied in the masonry by portions of adjacent masonry.

(*b*) The compressive strengths of floor tile and/or non-load-bearing tile shall be taken as the maximum load in pounds, divided by the net cross-sectional area in square inches. The net area of a tile is the area of the fired clay in the section of minimum area taken perpendicular to the direction of the load.

(*c*) The results shall be reported separately for each specimen, with the average for the five specimens.

ABSORPTION TESTS

Test Specimens

12. (*a*) The specimens for the absorption test shall consist of five tile or three representative pieces from each of these five tile. If small pieces are used, two shall be taken from the shell and one from an interior web, the weight of each piece to be not less than 227 g. (0.5 lb.). The specimens shall have had their rough edges or loose particles ground off and be free from cracks from the failure of the tile in compression, where taken from tile which have been subjected to strength tests.

Identification

(*b*) Each specimen shall be marked so that it may be identified at any time with the tile from which it was taken. Markings which do not cover more than 5 per cent of the total superficial area of the specimen shall be used.

Accuracy of Weighings

13. The balance used shall be sensitive to within 0.2 per cent of the weight of the smallest specimen tested.

Procedure

14. (*a*) *Drying.*—All specimens shall be dried to constant weight in a drier or oven at a temperature of not less than 100 C. (212 F.).

(*b*) *Saturation.*—After obtaining the dry weight of the specimens they shall be immersed in soft, distilled or rain water, the temperature raised to the boiling point and the water boiled continuously for 1 hr. The specimens shall then be allowed to cool in the water to room temperature.

(*c*) *Weighing.*—After saturation, the specimens shall be removed from the water and allowed to drain for not more than 1 min. The superficial water shall then be removed from the specimens with a damp cloth, after which they shall be weighed immediately.

Calculating and Reporting Results

15. The absorption shall be calculated as a percentage of the initial dry weight, carried to the nearest first decimal place. The results shall be reported separately for each tile, with the average for the five tile.

FREEZING-AND-THAWING TESTS

Preparation of Specimens

16. The specimens for the freezing-and-thawing test shall consist of five tile or of a cell not less than 4 in. in length sawed from each of these five tile. The specimens shall be saturated by immersion in cold water for at least 72 hr. prior to starting the freezing.

Procedure

17. Any practical method of obtaining alternate freezings and thawings may be used, the freezings to be always made with fully saturated specimens and the time and temperature to be such as to insure full freezing and thawing throughout the specimen. The initial weighing and all weighings for loss of weight shall be made on dry specimens.

Accuracy of Weighings

18. The balance used shall be sensitive to within 0.1 per cent of the weight of the smallest specimen tested.

Interpretation of Results

19. Failure under the freezing-and-thawing treatment shall be considered to be reached when:

(*a*) The specimens show superficial disintegration or spalling with loss of weight of more than 5 per cent of the initial weight; or

(*b*) The specimens are badly cracked; or

(*c*) The specimens show evident loss of structural strength.

TENTATIVE SPECIFICATIONS

FOR

GROUND FIRE CLAY[1]

A.S.T.M. Designation: C 105 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications are intended to cover ground fire clays which are to be used in the laying-up of refractory clay brick.

Quality

2. The material shall be sufficiently free from grit and of such quality and plasticity that it will spread satisfactorily with a trowel when tempered with adequate water.

Grades

3. There are two grades of ground fire clay depending upon particle size as follows:

	DESIGNATION
Commercial Grade	C
Fine Grade	F

Particle Size

4. (*a*) *Commercial Grade.*—The commercial grade shall be of such a particle size that 90 per cent of the material shall pass a No. 20 A.S.T.M. sieve[2] (equivalent to Tyler standard series, mesh No. 20).

(*b*) *Fine Grade.*—The fine grade shall be of such a particle size that 90 per cent of the material shall pass a No. 30 A.S.T.M. sieve[2] (equivalent to Tyler standard series, mesh No. 28).

Classes

5. There shall be four classes of ground fire clay depending upon the grade of refractories with which they are to be used. These

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-8 on Refractories.

[2] For detailed specifications for these sieves, see the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

classes shall conform to the following requirements as to Pyrometric Cone Equivalent:

High-heat duty class[a]	not below Standard Pyrometric Cone No. 28
Intermediate duty class[a]	not below Standard Pyrometric Cone No. 26
Moderate-heat duty class[a]	not below Standard Pyrometric Cone No. 20
Low-heat duty class[a]	not below Standard Pyrometric Cone No. 16

---

[a] Each class shall be suffixed by the designating letter C (Commercial Grade) or F (Fine Grade) depending upon the particle size required.

Methods of Testing

6. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Particle Size.*—The procedure for wet sieve analysis as described in Sections 6 to 8 of the Tentative Method of Test for Particle Size of Ground Refractory Materials (A.S.T.M. Designation: C 92 - 32 T).[1]

(*b*) *Pyrometric Cone Equivalent.*—Standard Method of Test for Softening Point of Fire-Clay Brick (A.S.T.M. Designation: C 24)[2] and also the existing tentative revision.[3]

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 721 (1932); also 1934 Book of A.S.T.M. Tentative Standards, p. 388.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 184.

[3] See p. 1263.

TENTATIVE SPECIFICATIONS
FOR
REFRACTORIES FOR THE CONSTRUCTION OF INCINERATORS[1]

A.S.T.M. Designation: C 106 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications are intended for selection of clay fire brick for use in the construction of incinerators.

Grades

2. In these specifications, clay fire brick are divided into siliceous and non-siliceous grades (Note), but no other definite requirement is stipulated as to analysis, as no definite relation between analysis and service has been demonstrated.

NOTE.—Brick are considered as being of siliceous grade when the silica content is more than 65 per cent and of non-siliceous grade when the silica content is 65 per cent or less.

REQUIREMENTS OF REFRACTORIES FOR MAIN BODY OF THE FURNACE, CROWN AND TARGET WALL

Pyrometric Cone Equivalent (Fusion Point)

3. (*a*) The Pyrometric Cone Equivalent shall not be below Standard Pyrometric Cone No. 31 in the case of the non-siliceous grade, and not below Standard Pyrometric Cone No. 28 in the case of the siliceous grade (see Note, Section 2).

(*b*) In the event that the material fails to pass the specified requirements by one cone or less, two additional Pyrometric Cone Equivalent determinations shall be made as checks on the accuracy of the test and the final results judged on the basis of the three determinations. This procedure is necessary because of variations that have been found to exist in this test even where the standard methods are followed.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-8 on Refractories.

Linear Change

4. When duplicate samples are heated in a period of 3 hr. to 1400 C. and maintained at this temperature for 5 hr. and cooled, they shall not show an average contraction from the original length of more than 1.5 per cent.

Spalling

5. When subjected to the panel spalling test, the average spalling loss of the 14 test brick shall not be greater than 15 per cent.

REQUIREMENTS OF REFRACTORIES FOR LINING OF CHIMNEYS

Grades

6. Depending upon the particular conditions and upon the margin of safety desired, the brick may be of the same grade as used in the main body of the furnace, or one of the following grades:

	GRADE A	GRADE B	GRADE C
Pyrometric Cone Equivalent, not under Standard Pyrometric Cone	No. 28	No. 26	No. 18
Modulus of rupture, min., lb. per sq. in	450	500	500

Methods of Testing

7. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Silica Content.*—Standard Methods of Ultimate Chemical Analysis of Refractory Materials, Including Chrome Ores and Chrome Brick (A.S.T.M. Designation: C 18);[1]

(*b*) *Pyrometric Cone Equivalent.*—Standard Method of Test for Softening Point of Fire-Clay Brick (A.S.T.M. Designation: C 24)[2] and the existing tentative revision;[3]

(*c*) *Panel Spalling Test.*—Tentative Method of Panel Test for Resistance to Thermal and Structural Spalling of Fire-Clay Brick for Stationary Boilers and Malleable Iron Furnace Bungs (A.S.T.M. Designation: C 107 - 34 T);[4]

(*d*) *Modulus of Rupture.*—The flexure test as described in Sections 8 to 12 of the Standard Methods of Testing Brick (Compression, Flexure, Absorption) (A.S.T.M. Designation: C 67).[5]

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 165.

[2] *Ibid.*, p. 184.

[3] See p. 1263.

[4] See p. 804.

[5] 1933 Book of A.S.T.M. Standards, Part II, p. 128.

TENTATIVE METHOD OF CHEMICAL ANALYSIS OF MAGNESITE REFRACTORIES[1]

A.S.T.M. Designation: C 18 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Solutions Required

1. Concentrated or undiluted reagents of approximately the following specific gravities or concentration will be required:

Hydrochloric acid, HCl	1.19 sp.gr.
Sulfuric acid, H_2SO_4	1.84 sp.gr.
Nitric acid, HNO_3	1.42 sp.gr.
Hydrofluoric acid, HF	40 per cent
Perchloric acid, $HClO_4$	60 to 70 per cent, c.p.[a]
Ammonium hydroxide, NH_4OH	0.90 sp.gr.

[a] Lower purity varieties may contain aluminum oxide, Al_2O_3, as an impurity.

2. The dilute reagents referred to are of varying percentages by volume. They shall be made up by mixing proportional volumes of the concentrated reagent and water. The dilute sulfuric acid mixtures shall be made up by slowly stirring the acid into the water. The following dilute reagents will be required:

	PERCENTAGE BY VOLUME
Hydrochloric acid	50 20 2.5
Sulfuric acid	50 10 5
Nitric acid	30 3
Ammonium hydroxide	50 5

3. The following solutions will be required:

(*a*) *Ammonium Chloride Solution* (*1 per cent*).—Dissolve 1 g. in 100 ml. of water.

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee C-8 on Refractories.

This method, when adopted as standard, will be added to the present Standard Methods of Ultimate Chemical Analysis of Refractory Materials, Including Chrome Ores and Chrome Brick (A.S.T.M. Designation: C 18 - 21), 1933 Book of A.S.T.M. Standards, Part II, p. 165.

(*b*) *Ammonium Oxalate Solution* (*Saturated*).—Dissolve 4 g. in 100 ml. of water.

(*c*) *Alcohol* (*Absolute*).—Certain commercial brands of denatured absolute are satisfactory as well as being considerably less expensive than the c.p. absolute.

(*d*) *Potassium Permanganate Solution* (*Approximately 0.5 N*).—Dissolve 16 g. in 1000 ml. of water.

(*e*) *Standard Potassium Permanganate Solution* (*0.1 N*).—Dissolve 3.25 g. in 1000 ml. of water. Standardize as described in Section 10 of the Standard Methods of Ultimate Chemical Analysis of Refractory Materials, Including Chrome Ores and Chrome Brick (A.S.T.M. Designation: C 18) of the American Society for Testing Materials.[1]

(*f*) *Stannous Chloride Solution*.—Dissolve 50 g. of $SnCl_2$ in 100 ml. of HCl and dilute to 1000 ml. Keep a few pieces of metallic tin in the bottle.

(*g*) *Mercuric Chloride Solution*.—A saturated solution.

(*h*) *Manganese Sulfate Solution*.—Dissolve 70 g. of crystalline $MnSO_4$ in 500 ml. of water. Add 140 ml. of phosphoric acid, H_3PO_4 (sp. gr. 1.7) to 130 ml. of H_2SO_4 (sp. gr. 1.84) and dilute to 1000 ml.

(*i*) *Ammonium Chloride - Hydrochloric Acid Solution*.—Dissolve 50 g. of NH_4Cl in water, add 50 ml. of HCl (sp. gr. 1.19) and dilute to 1000 ml.

(*j*) *Standard Sodium Arsenite Solution*.—Dissolve 0.908 g. of pure arsenious oxide, As_2O_3, in a small amount of hot Na_2CO_3 solution, cool, filter, and make up to 1 liter. Standardize against a steel of known manganese content.

Preparation of Samples for Analysis

4. A 5-lb. sample carefully secured after the manner of one of the approved methods of sampling shall be crushed to pass a No. 8 sieve,[2] mixed thoroughly, and reduced by quartering to about 0.5 lb. This shall be crushed to pass a No. 20 sieve,[2] mixed and quartered to about 50 g. This 50-g. sample shall then be ground in an agate mortar so that it will all pass a No. 100 sieve,[2] mixed thoroughly and placed in an air-tight container until analyzed, since finely ground, dead-burned magnesite gradually absorbs and fixes moisture and carbon dioxide.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 165.

[2] For detailed specifications for these sieves, see the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

Hygroscopic Moisture

5. Heat a 2-g. portion of the air-dried sample in a platinum crucible for 1 hr. at 105 to 110 C. Record the loss in weight as hygroscopic moisture.

Loss on Ignition

6. Using the sample from which the hygroscopic moisture has been removed (Section 5), heat it to constant weight over a blast lamp or in an electric furnace at 900 to 1000 C. Record the loss in weight as the ignition loss, which is calculated to the moisture-free basis as are all subsequent determinations.

Silica

7. Transfer 1 g. of the moisture-free sample, or the equivalent of the ignited residue from the loss on ignition determination (Section 6), to a 210-ml. casserole. Moisten the solids with a few milliliters of water and slowly add 20 ml. of HCl, cover the casserole. While covered, digest on the hot plate until solution is complete and all gritty particles have disappeared, breaking up any solid cake from time to time with a stirring rod. Uncover, add 8 ml. of perchloric acid, $HClO_4$ (60 to 70 per cent), and evaporate to heavy white fumes of $HClO_4$. Cover and boil so that acid refluxes for 10 to 15 minutes. Remove from the hot plate, cool, wet with a few milliliters of water and 5 ml. of HCl, warm for a few minutes on the hot plate, add 50 ml. of hot water, heat to approximately boiling and filter through a 9-cm. rapid filter. Wash the paper and precipitate ten times with a hot HCl solution (2½ per cent), then three times with hot water. Return the filtrate to the casserole in which the first evaporation was made, add 2 ml. of perchloric acid (60 to 70 per cent) and evaporate to fumes on the hot plate, boiling as before. Cool, take up in acid and water, filter, and wash as before. Reserve the filtrate. Place both papers and precipitates in a tared platinum crucible. Dry, then burn off papers and ignite to constant weight in the muffle or over a moderate blast. Cool in a desiccator and weigh as impure silica. Add 2 drops of H_2SO_4 (1:1) to the impure silica in the crucible, and 1 ml. of HF. Digest for 5 to 10 minutes, covered, on the hot plate, then remove the cover and evaporate to dryness. Fume off the H_2SO_4 over a moderate heat and ignite or blast for a few minutes. Cool in a desiccator and weigh again. Subtract the weight of the crucible and residue from the weight of the crucible and impure silica and the difference is the silica. Fuse the residue in the crucible by heating gently with a small piece of potassium pyrosulfate, $K_2S_2O_7$, or sodium pyrosulfate, $Na_2S_2O_7$, about the size of a pea, cool, dissolve in water and add to the reserved filtrate from the silica.

Iron and Aluminum Oxides

8. Add to the filtrate from the silica determination (Section 7), which should be in a 400-ml. beaker, 5 g. of NH_4Cl. Dilute from 150 to 200 ml., add 3 drops of methyl red solution (0.1 per cent), heat to boiling, add NH_4OH (1:1) slowly; finally drop by drop, until the solution is just alkaline to the indicator. Boil for 1 or 2 minutes and filter through a 9-cm. rapid filter. Do not wash. Reserve the filtrate. Transfer the paper and precipitate to the beaker in which the precipitation was made, add 50 ml. of HCl (1:4) and digest covered on the hot plate, shaking frequently until the precipitate is dissolved and the paper well macerated. Dilute, add methyl red, reprecipitate with NH_4OH (1:1), boil and filter, exactly as before. Add this second filtrate to the first filtrate for the subsequent determination of lime (Section 11). Swab the beaker and rod and wash the paper and precipitate with NH_4Cl solution (1 per cent). Dry, then ignite the paper and precipitate in a tared platinum crucible at 1000 to 1100 C. for 1 hr. with access of air. Cool in a desiccator and weigh as R_2O_3 which is mainly the iron and aluminum oxides.

Iron Oxides

9. Weigh 2 g. of the sample into a 150-ml. beaker and cover. Dissolve by slowly adding HCl, keeping the beaker on the hot plate. Finally, add about 5 ml. of HCl in excess. Heat to gentle boiling until the siliceous residue undissolved appears iron-free. Filter and fuse the residue with a very little potassium pyrosulfate, $K_2S_2O_7$, or sodium pyrosulfate, $Na_2S_2O_7$, in a porcelain or vitreous silica crucible to avoid introducing platinum. Dissolve the fused material and add to the filtrate. Add a few drops of a strong solution of potassium permanganate, $KMnO_4$ (about 0.5 N), to oxidize any organic matter that may be present. Boil. When the excess of $KMnO_4$ is decomposed and chlorine fumes have disappeared, reduce the iron by adding stannous chloride, $SnCl_2$ solution, drop by drop from a pipette with constant swirling of the beaker, until the solution is colorless, then add 1 drop in excess. Cool quickly in running water, then add at one stroke 15 ml. of saturated mercuric chloride solution. Allow to stand for 3 minutes, transfer with washing to a 600-ml. beaker containing 300 ml. of cold distilled water and 25 ml. of $MnSO_4$ solution. Titrate with standard 0.1 N $KMnO_4$ solution, added very slowly while stirring, until a permanent pink end-point is obtained. Correct for a blank on the reagents carried through all the operations and calculate the remainder to iron oxide, Fe_2O_3.

Aluminum Oxide

10. Subtract the calculated weight of iron oxide, Fe_2O_3, (Section 9) from the weight of R_2O_3 (Section 8) and the remainder is the weight of the aluminum oxide, Al_2O_3, plus small amounts of oxides of any other elements that were precipitated (Note).

NOTE.—These may include P_2O_5, TiO_2 and small amounts of SiO_2, but they are present in such small amounts as to be disregarded in the complete analysis of magnesite refractories.

Lime

A. Method When Magnesium Oxide, MgO, is to be Determined Directly:

11. Acidify with several milliliters of HCl (50 per cent) the combined filtrate from the R_2O_3 precipitation (Section 8) and evaporate to a volume of about 250 ml. Heat to incipient boiling, add 25 ml. of a saturated ammonium oxalate, $(NH_4)_2C_2O_4$, solution (about 4 per cent) and NH_4OH until slightly alkaline. Stir thoroughly and allow the precipitate to settle out, keeping the solution warm for 3 to 4 hr. but not boiling. Filter and wash five times with cold water. Save the filtrate. Dissolve the washed oxalate precipitate with 50 ml. of dilute HCl (1:1), dilute to 250 ml. and precipitate as before. Wash the beaker, precipitate and paper with cold water until ammonium oxalate is removed. Avoid excessive washing. Combine the filtrates for the magnesia determination (Section 13). To the beaker used for the precipitation, add 150 ml. of a H_2SO_4 solution (5 per cent), then introduce the paper containing the precipitate. Heat to almost boiling and titrate with 0.1 *N* $KMnO_4$ solution. A blank should be previously determined for the effect of the paper.

A small part of the lime occasionally escapes the oxalate precipitation and comes down subsequently with the magnesia. To the lime precipitated by the oxalate should accordingly be added that found in the magnesia.

B. Method When Magnesium Oxide, MgO, is to be Determined by Difference:

NOTE.—In this specific procedure very much less lime escapes precipitation and thus the magnesia "by difference" is not subject to this plus error. The procedure further has the advantage that an individual lime determination may be made without separating the other usual constituents.

12. Weigh 2.5 g. of the sample into a 250-ml. beaker, add 10 ml. of water, cover, slowly add HCl until dissolved, stirring frequently and avoiding excessive boiling. Then add about 5 ml. of HCl in excess. Evaporate on a hot plate until very thick and syrupy. At this stage crusts will be forming on the surface and a drop of material placed on

the wall of the beaker will immediately solidify. Remove the beaker from the hot plate and allow to partially cool. Add 5 ml. of H_2SO_4 solution (10 per cent). Cover with a watch glass, heat on a hot plate until all soluble matter is dissolved. Cool slightly but not until solids separate. Add 50 ml. of alcohol, stir thoroughly and heat just to boiling on a hot plate. Filter with suction through a Gooch crucible prepared with a moderately thin asbestos mat. If the SiO_2 is less than 3.5 per cent, filter through paper. Rinse the beaker twice with alcohol pouring the washings through the crucible. Drain under suction. Remove the crucible, scrape out the mat with a glass rod into the beaker in which the precipitation of sulfate was made, wash the crucible clean with a hot ammonium chloride - hydrochloric acid solution, using about 35 ml. If the SiO_2 is high (over 6 per cent) it is advisable to filter it off at this point before precipitating the lime. Dilute to about 150 ml. with hot water, make alkaline with NH_4OH, heat to boiling and precipitate the calcium by slowly adding 15 ml. of a saturated solution of ammonium oxalate. Digest on the hot plate just below boiling for 30 minutes. Filter on a 9-cm. paper, wash with cold water until free from oxalate, testing final washing with a drop of permanganate after acidification. Transfer the paper and precipitate to the original beaker, dissolve with 150 ml. of H_2SO_4 (5 per cent) and titrate as in Method A, Section 11. Correct for a blank on the paper and reagents carried through all the operations and calculate the remainder to CaO.

Magnesium Oxide

13. Acidify with several milliliters of HCl (50 per cent) the combined filtrates reserved during the determination of lime (Section 11). Dilute to 500 ml. in a calibrated flask and take a 50 ml. ($\frac{1}{10}$) aliquot portion. Since a 1-g. sample was originally used, this will yield aliquot portions containing between 0.08 to 0.09 g. of magnesium oxide. Dilute to 250 ml. and add 2 to 3 g. of diammonium phosphate, $(NH_4)_2HPO_4$. Stir until dissolved and then add NH_4OH slowly until alkaline and then 30 ml. of NH_4OH in excess. Allow the solution to stand for at least 4 hr., and preferably overnight if the total amount of solution exceeds 400 ml. in volume. Filter, wash with dilute NH_4OH solution (5 per cent). Dissolve from the paper with hot HCl (1:1) and reprecipitate by adding 0.1 g. of $(NH_4)_2HPO_4$, diluting, rendering ammoniacal and letting stand as before. After filtering and washing as before, char the paper and burn off the carbon at temperatures below 900 C. and then ignite

in an electric muffle furnace at about 1100 C. to constant weight. The ignited material consists of magnesium pyrophosphate, $Mg_2P_2O_7$ as well as some of the CaO and MnO. Correction may be made for these as follows:

Dissolve the ignited pyrophosphate in a little dilute H_2SO_4 and add enough absolute alcohol to make up 90 to 95 per cent of the final volume. Any calcium present will settle out as $CaSO_4$. Filter, wash with alcohol and dissolve the precipitate in hot dilute HCl. Precipitate with oxalate and titrate with permanganate. Add this CaO to that previously found. The CaO is then calculated to tricalcium phosphate, $Ca_3(PO_4)_2$, by multiplying by the factor 1.845 and this amount deducted from the weight of the $Mg_2P_2O_7$. The correction to the first calcium precipitate is ten times the weight of the CaO precipitated as sulfate.

The manganese which contaminates the $Mg_2P_2O_7$ is determined in the alcoholic filtrate from the $CaSO_4$. Evaporate this filtrate until strong fumes are evolved and all organic matter destroyed. Cool, dissolve the residue in 25 ml. of HNO_3 (30 per cent) and determine the manganese by the bismuthate method, as described in Section 14. Any manganese found is calculated to $Mn_2P_2O_7$ by multiplying by the factor 2.585 and this weight deducted from the $Mg_2P_2O_7$.

Manganese as MnO

14. Mix intimately 1 to 5 g. of the sample (depending upon the amount of manganese expected) with 0.5 to 2.5 g. of anhydrous sodium carbonate, Na_2CO_3, and ignite in a platinum crucible for 15 min. at about 1000 C. Dissolve the sintered melt in 50 ml. of HNO_3 (30 per cent) and add dropwise a solution of SO_2 in water, if there is any evidence of brown hydrated MnO_2. Boil the solution, filter if necessary, cool to room temperature or lower, and add 2 to 3 g. of sodium bismuthate. Agitate the solution for one minute and filter through asbestos (Note). Wash with a HNO_3 solution (3 per cent) until the residue is free from permanganic acid, as determined by the absence of the pink color in the washings. Titrate, at once, the permanganic acid formed, with standard sodium arsenite (1 ml. = 0.0002 g. of Mn). The end point is the disappearance of the pink color. The factor for converting Mn to MnO is 1.291.

NOTE.—A good grade of asbestos, acid washed, and specially prepared for Gooch crucibles, should be used.

TENTATIVE METHODS OF TESTING HIGH-TEMPERATURE HEAT INSULATION[1]

(COMPRESSION, FLEXURE, SHRINKAGE)

A.S.T.M. Designation: C 93 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1933; Revised, 1934.

Scope

1. These methods cover the following tests for high-temperature insulation:

Compression test;
Flexure or cross-bending test; and
Shrinkage test.

Compression Test

Apparatus

2. Any form of standard testing machine may be used for the compression test together with a spherical bearing block large enough entirely to cover the specimen.

Test Specimen

3. The test specimen shall preferably consist of a half-brick measuring 4½ by 4½ by 2½ in. If a specimen having dimensions other han these is used, they shall be reported.

Note.—This permits the use of a suitable half-brick from the flexure test.

Condition of Test Specimen

4. The surfaces of the material to be tested shall be true planes and parallel.

Number of Tests

5. Compression tests shall be made on at least ten half-brick test specimens from different bricks.

Procedure

6. (*a*) The half-brick test specimen shall be tested, placed flat.

(*b*) The bearing block shall be used on top of the test specimen in vertical testing machines. The center of the sphere of the bearing block shall be used in contact with the top bearing surface of the specimen, and in the vertical axis of the specimen. (See Fig. 1.) The spherical bearing block shall be kept thoroughly lubricated to insure accurate adjustment, which should be made by hand under a small initial load.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee C-8 on Refractories.

(*c*) The speed of the moving head of the testing machine, during the application of the load, shall not be more than 0.05 in. per minute.

(*d*) During the test the beam of the testing machine shall be kept constantly in a floating position.

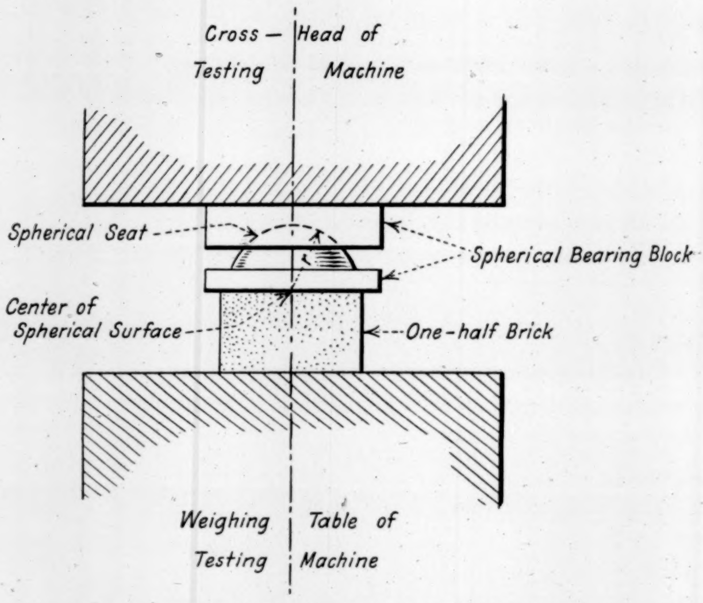


FIG. 1.—Spherical Bearing Block for Compression Test.

(*e*) The test specimen shall be compressed to a deformation of 5 per cent of the original thickness, unless definite failure shall have previously occurred. The load value reported shall be the maximum obtained.

Compressive Strength

7. The compressive strength in pounds per square inch shall be reported as the total maximum load, W, in pounds, indicated by the testing machine, divided by the average of the gross areas of the top and bottom of the specimen, A, in square inches, of the section of the specimen perpendicular to the line of application of the load.

The compressive strength in pounds per square inch shall be calculated from the formula:

$$\text{Compressive strength} = \frac{W}{A}$$

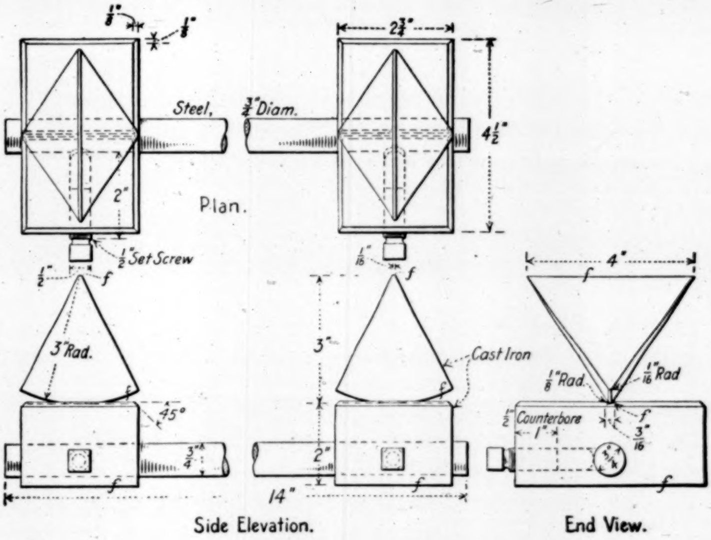
FLEXURE TEST

Apparatus

8. (*a*) Any form of standard testing machine with knife edges as described in Paragraph (*b*) may be used for the flexure test.

NOTE.—Portable apparatus properly calibrated may be used.

(*b*) Knife edges shall be straight and have full contact with the specimen or bearing plate and they shall have a length at least equal to the width of the brick to be tested. Their bases shall be so curved or rounded as to permit free movement of the working edges, both longitudinally and transversely. The use of knife edges of the type shown in Fig. 2 is recommended, although other types may be used which will provide free movement and at the same time insure full and even bearing at all times during the test.



$\frac{1}{8}$"
$\frac{1}{8}$"
$2\frac{3}{4}$"
Steel, $\frac{3}{4}$" Diam.
$4\frac{1}{2}$"
2"
Plan.
$\frac{1}{2}$" Set Screw
$\frac{1}{2}$"
f
$\frac{1}{16}$"
f
4"
f
3" Rad.
3"
Cast Iron
$\frac{1}{8}$" Rad.
$\frac{1}{16}$" Rad
f
f
45°
1
$\frac{1}{2}$" Counterbore
1"
f
$\frac{3}{16}$"
$\frac{3}{4}$"
2"
$\frac{3}{4}$
f
f
f
14"
Side Elevation.
End View.

FIG. 2.—Knife-Edge Bearing Device.

Test Specimen

9. The test specimen shall preferably be 9 by $4\frac{1}{2}$ by $2\frac{1}{2}$ in. If a specimen having dimensions other than these are used, they shall be reported.

Number of Tests

10. Flexure tests shall be made on at least ten test specimens.

Procedure

11. (*a*) A test specimen shall be placed flat-wise on the knife edges with a span of 7 in. and the load applied at mid-span.

(*b*) A steel bearing piece $\frac{1}{4}$ in. in thickness, $1\frac{1}{2}$ in. in width and of a length equal to the full width of the specimen shall be placed between the upper knife edge and the specimen.

(*c*) The speed of the moving head of the testing machine, during the application of the load, shall not be more than 0.05 in. per minute.

Modulus of Rupture

12. The modulus of rupture, R, in pounds per square inch shall be reported as calculated from the following formula:

$$R = \frac{3\ Wl}{2\ bd^2}$$

where W = the total load in pounds at which the brick failed;
l = the distance between the supports in inches;
b = the width of the brick in inches; and
d = the depth of the brick in inches.

SHRINKAGE TEST

Scope

13. The object of this test is to determine the permanent heat shrinkage of the specimen when subjected to a definite temperature.

Test Furnace

14. The test furnace may be any suitable furnace in which uniform temperatures can be obtained.

15. The test specimen shall preferably be 9 by $4\frac{1}{2}$ by $2\frac{1}{2}$ in. If a specimen having dimensions other than these is used, they shall be reported.

Procedure

16. (*a*) The test specimen shall be measured along the three major axes through the center of the specimen. The measurements shall be made to the nearest 0.01 in.

(*b*) The test specimen shall be placed in the furnace preferably on the 9 by $2\frac{1}{2}$-in. edge, resting on a slab of the same composition whose thickness shall be not less than 1 in. The test specimen shall be protected from direct flame or localized heating from direct contact with furnace parts.

(*c*) The maximum temperature to be used shall depend upon the material. This maximum temperature shall be obtained in not less than 3 hr. The maximum temperature shall be held for a period of 24 hr. The specimen shall be left in the furnace until the furnace temperature has fallen to at least 500 F. (260 C.).

Volume Shrinkage

17. (*a*) The lineal shrinkage shall be calculated from measurements taken along the three major axes. The shrinkage in length, width, and thickness shall be reported separately. The lineal shrinkage shall be calculated on the basis of each original dimension.

(*b*) The volume shrinkage shall be calculated from the measurements along the three major axes through the center of the specimen, in accordance with the following formula:

$$\text{Volume shrinkage, per cent} = \frac{V_o - V_f}{V_o} \times 100$$

where V_o = the original volume; and
V_f = the final volume.

Linear Shrinkage

18. The linear shrinkage shall be calculated from the volume shrinkage by the following formula:

$$L = 100\left[1 - \sqrt[3]{1 - \frac{V}{100}}\right]$$

TENTATIVE METHOD OF PANEL TEST
FOR
RESISTANCE OF REFRACTORY BRICK TO THERMAL AND STRUCTURAL SPALLING[1]

A.S.T.M. Designation: C 38 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1921; REVISED, 1926, 1927, 1931, 1933, 1934.

Scope

1. This method of test is intended to show the resistance of refractory brick to the separate and combined effects of structural and thermal spalling. The test is believed to give a sufficient simulation of service conditions to suggest its use as a suitability test for certain classes of service that have been correlated with the test data (Note).

NOTE.—Such correlation is now available in the case of high-heat-duty clay brick for stationary boiler and malleable iron furnace bungs.

Apparatus

2. The following apparatus and equipment[2] will be required:

(*a*) *Panel Frame.*—A panel framework shall be used which is essentially the same as that shown in Fig. 1.

(*b*) *Preheating Furnace.*—A preheating furnace shall be used, constructed essentially like the design shown in Figs. 2 and 3.

(*c*) *Spalling Furnace.*—A spalling furnace shall be used, constructed in a manner as shown in Figs. 4, 5 and 6.

(*d*) *Temperature Measuring Instruments.*—The temperature of the test panel during the preheating shall be measured by means of an optical pyrometer. The spalling furnace temperature shall be determined by means of a platinum, platinum-rhodium thermocouple.

(*e*) *Air Supply.*—Means shall be provided for delivering air through each cooling unit at a specified rate.

(*f*) *Transfer Facilities.*—A suitable means, such as a track or trolley, shall be provided for transferring the test panels.

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee C-8 on Refractories.

[2] The complete set of drawings necessary for the construction of the panel spalling equipment would require too much space to be included with the procedure, but these are available at a nominal charge from the Refractories Fellowship, Mellon Institute of Industrial Research, Pittsburgh, Pa.

Test Specimen

3. Whenever possible, the panel test specimen shall consist of 9-in. straight brick. When shapes of other sizes are to be tested, these shall be cut so as to be not more than 3 in. in thickness by 9 in. in length by 4½ in. in width.

Panel Construction

4. The test brick shall be laid up so as to form a panel not less than 18 in. square, so that a 9 by 2½-in. surface of each brick will be exposed to the heat treatment. Each test brick shall be labeled with ceramic paint on the face opposite that to be tested, and then weighed to the nearest 0.1 lb. There shall be placed about the panel test specimen a suitable grade of refractory dummy brick, in the manner shown in Fig. 1. The dummy brick shall extend ½ in. beyond the surface of the test panel. All brick in the test panel shall be laid up with refractory kaolin unless otherwise specified. The joints shall

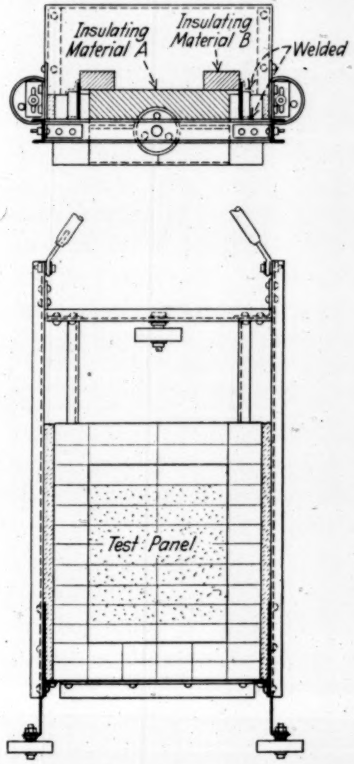


FIG. 1.—Panel Frame and Brickwork.
The brick around the test panel are dummy brick which are used to help maintain uniform conditions within the panel.

not be thicker than $\frac{1}{16}$ in. The insulation shall consist of a material suitable for service at 1300 C. and of a specified insulating value.

Preheating Test Panels

5. The prepared test panels shall be placed in position on either side of the preheating furnace. When only one lot of brick is to be tested, a dummy panel should be used. The joint between the ends of the panel dummy brick and the preheating furnace shall be sealed with plastic kaolin. During the heating of the panels, the surface of the test brick opposite that being heated shall be insulated in the specified manner so as to maintain a suitable temperature gradient in the test brick. The furnace is to be operated so that the temperature specified for preheating shall be reached in not less than 5 hr. nor more than 8 hr. and maintained 24 hr. The permissible variation in temperature may be +20 C. and −25 C., but the average of the temperature during the run shall be that specified. After completing the preheating, the test panel shall be left in position for not less than 8 hr. before being removed. As a result of this heat treatment, any tendency toward fusion, vitrification, swelling, or shrinkage will be evident and any development of structural spalling will be apparent. A record shall be made of the condition of the brick, indicating the extent of the fusion, vitrification, swelling, or shrinkage. If shrinkage takes place a record shall be made of its nature, that is, whether or not this occurs as a shrinkage of each brick as a unit, or as the development of cracks on the surface of each brick. The surface of the test panels may be photographed.

Spalling

6. The panels shall then be subjected to thermal spalling by heating them in a specified time to a specified temperature and rapidly cooling by means of a prescribed blast. The panels shall be placed in position in front of the spalling furnace in the manner shown in Figs. 5 and 6. The temperature of the spalling furnace shall be raised within 3 hr. to the specified temperature. During the heating period, the panels shall be alternately placed in position in front of the furnace so that each may be heated to about the same temperature. The position of the panels shall be changed at temperatures of 400, 200 and 100 C. below the final furnace temperature. During this period, the panels shall not be cooled by means of the cooling blast. After the final temperature of spalling is obtained, the panels shall be held in position for a specified time, and then shifted so as to expose the heated panel for cooling. After each panel has been

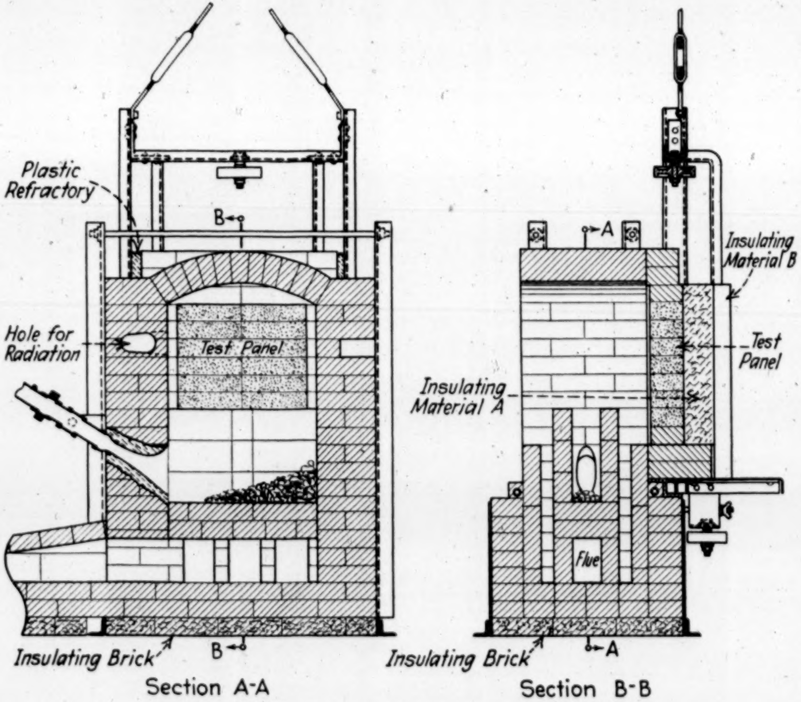

Plastic Refractory
Hole for Radiation
Test Panel
B
B
Insulating Brick
Section A-A
A
Insulating Material B
Test Panel
Insulating Material A
Flue
A
Insulating Brick
Section B-B

FIG. 2.—Design of Preheating Furnace.

In Section B-B there is shown in position one of the two panels used during the preheating.

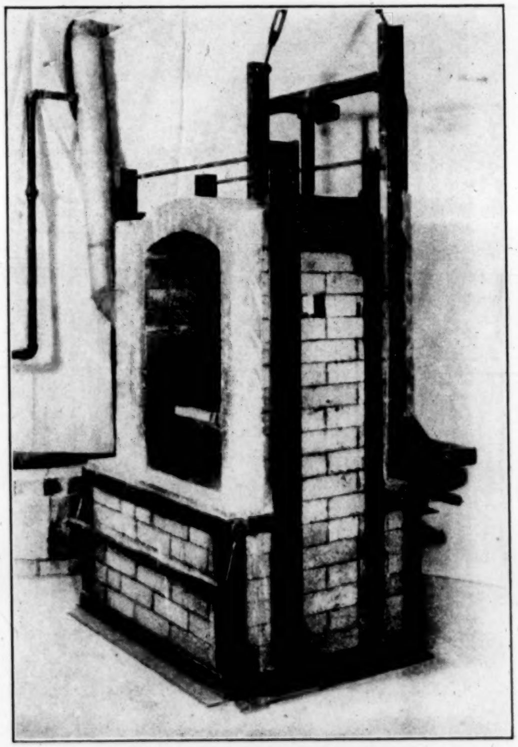


FIG. 3.—Preheating Furnace with Panel in Position on Far Side of Furnace.

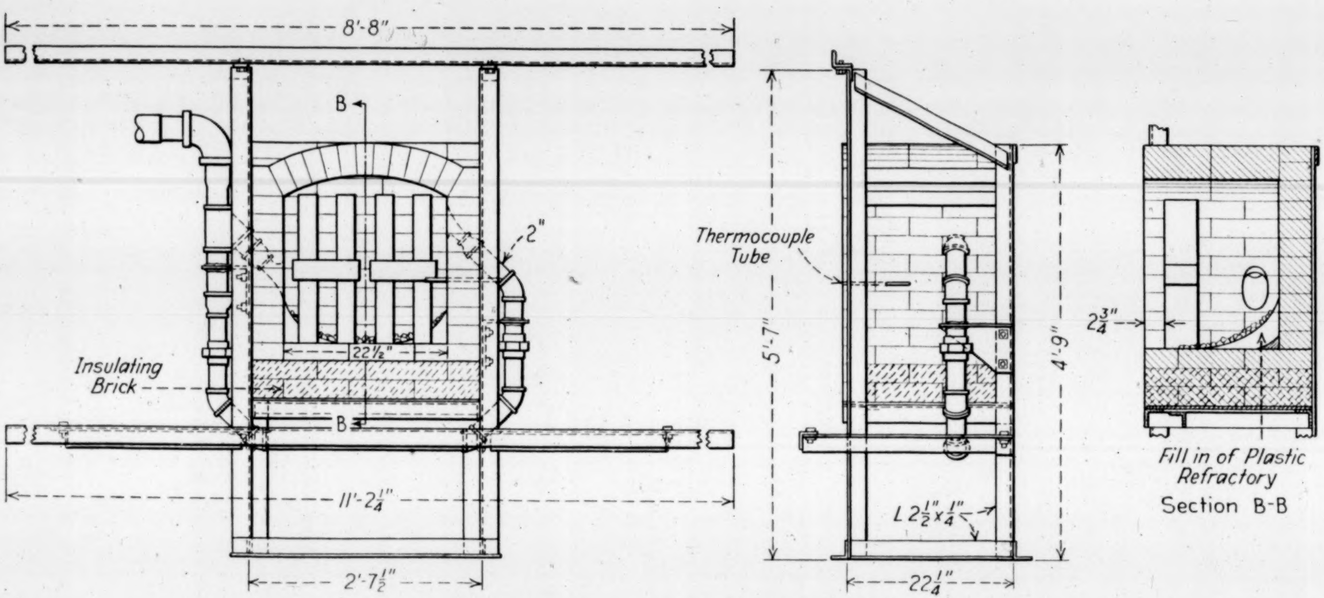

8'-8"
B
2"
22½"
Insulating Brick
B
11'-2$\frac{1}{4}$"
2'-7$\frac{1}{2}$"
Thermocouple Tube
5'-7"
4'-9"
L 2$\frac{1}{2}$" x $\frac{1}{4}$"
22$\frac{1}{4}$"
2$\frac{3}{4}$"
Fill in of Plastic Refractory
Section B-B

FIG. 4.—Furnace of the Spalling Equipment.

The complete layout is shown in Figs. 5 and 6.

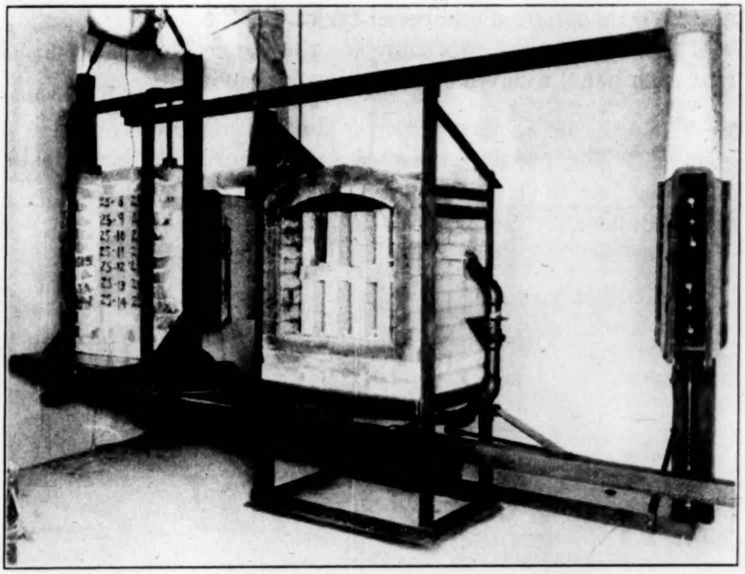


FIG. 5.—Spalling Equipment for Panel Spalling Test.

Front view showing one of the two panels in position. During the test a second panel is placed in front of the furnace opening. The two panels are linked together so that when the one which is now in the position for cooling is moved in front of the furnace, the other panel will be in position in front of the right-hand cooling unit. By this means, each panel is alternately heated and cooled.

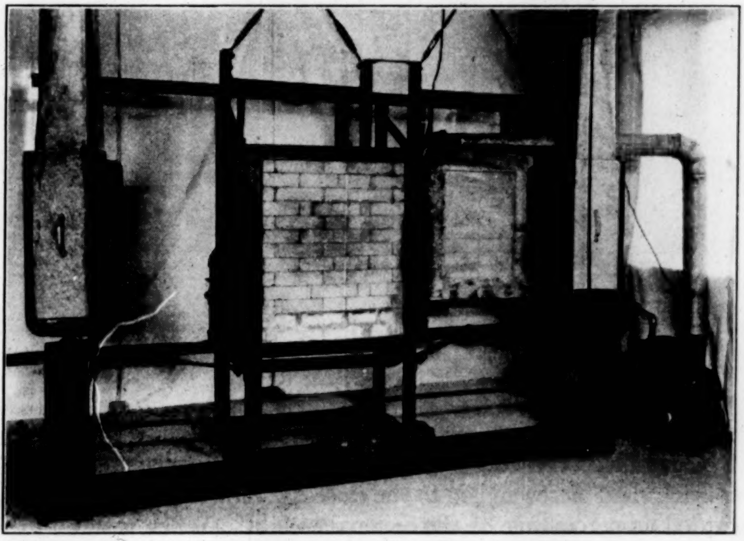


FIG. 6.—Cooling Equipment for Panel Spalling Test.

View from the back of the furnace showing the panels in position. There is shown the nature of the mechanism which causes the air manifolds to operate with a reciprocating motion and the motor blower unit used to operate the furnace.

subjected to the required number of cycles, the furnace shall be allowed to cool, but the cooling procedure for the panels shall be conducted so that each panel receives two additional periods.

Dismantling the Panels

7. When the panels have cooled sufficiently so that the brick can be handled, the test panel shall be carefully dismantled. The test brick shall be reweighed to the closest 0.1 lb., and the loss in weight recorded as percentage of the original weight. When a second treatment is given and the brick have been numbered from 1 to 7 from top to bottom in the panel, their order shall be changed so as to assume

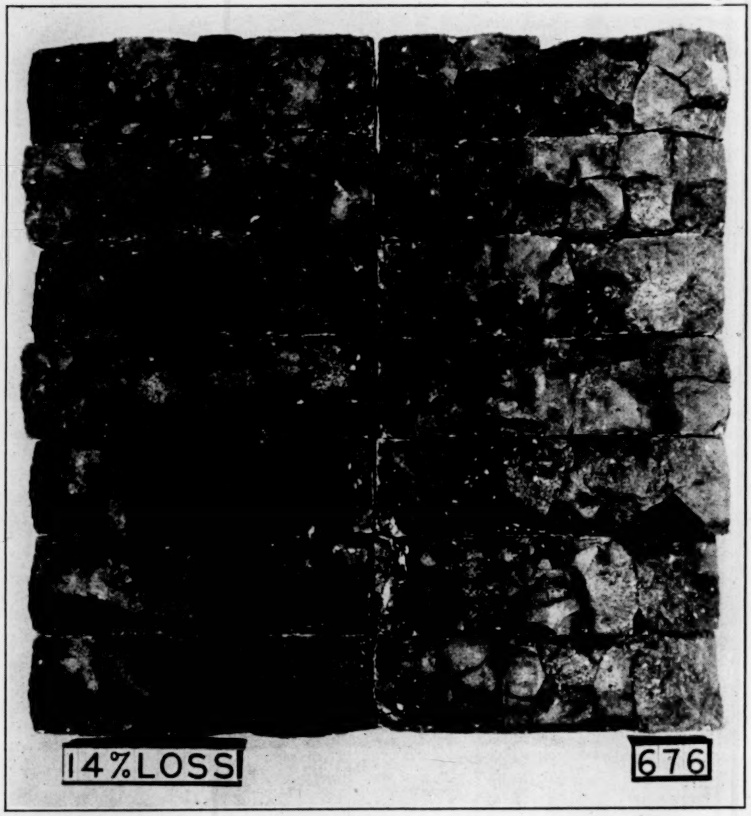


FIG. 7.—Photograph Showing Manner in Which Test Brick Are to Be Arranged for Making Photographic Report.

The brick are in the same corresponding position as laid up in the panel. The percentage loss and photograph number or designation are also shown.

the positions of 4–3–2–1–7–6–5. They shall also be turned end for end.

Report

8. The report may include a photograph of the panel after preheating, and shall include comments as to its condition. The average spalling loss for the whole panel shall be given, as well as a photograph of the spalled brick arranged in the manner shown in Fig. 7.

TENTATIVE METHOD OF PANEL TEST
FOR
RESISTANCE TO THERMAL AND STRUCTURAL SPALLING OF FIRE-CLAY BRICK FOR STATIONARY BOILERS AND MALLEABLE IRON FURNACE BUNGS[1]

A.S.T.M. Designation: C 107 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1934.

Scope

1. This method is intended to show the resistance of fire-clay brick used for stationary boilers and malleable iron furnace bungs to the separate and combined effects of structural and thermal spalling. This method makes use of the general requirements and procedure prescribed in the Tentative Method of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling (A.S.T.M. Designation: C 38 - 34 T) of the American Society for Testing Materials,[2] and supplements that method by giving the detailed requirements of the procedure to be followed in testing refractories for use in stationary boilers and malleable iron furnace bungs.

Apparatus and Test Specimen

2. The apparatus and test specimen shall be in general as described in the Tentative Method of Panel Test for Resistance of Refractory Brick to Thermal and Structural Spalling (A.S.T.M. Designation: C 38 - 34 T) of the American Society for Testing Materials.[2]

Procedure

3. The procedure shall be in general as outlined in the Tentative Method C 38 - 34 T,[2] supplemented by the procedure for preheating and spalling as prescribed in the following Sections 4 and 5.

Preheating

4. Details of the procedure for preheating shall be as follows:

(*a*) The test brick shall be laid up with kaolin having a Pyrometric Cone Equivalent not below Standard Pyrometric Cone No. 34.

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee C-8 on Refractories.

[2] See p. 796.

(*b*) The test panels shall be backed up with insulation, the thermal conductivity of which shall be such that the heat loss will be approximately 900 B.t.u. per square foot per hour. The mean temperature of the insulation shall be approximately 700 C.

(*c*) The temperature of the panel faces shall be maintained so as to average 1600 C. by means of a gas-fired furnace for a period of 24 hr.

Spalling

5. Details of the procedure for spalling shall be as follows:

(*a*) The panel insulation shall be removed.

(*b*) The gas-fired furnace shall be operated so as to obtain a temperature of 1400 C. before the panels are cooled by means of the blast.

(*c*) The period for heating shall be 10 min. and for cooling 10 min., making a 20-min. cycle.

(*d*) The cooling shall be accomplished by means of an air-water mist blast, which shall be delivered through a vertical manifold with an opening measuring $3\frac{1}{2}$ by 24 in. as shown in the Tentative Method C 38 – 34 T.[1] Air shall be delivered through each cooling unit at the rate of 1400 cu. ft. per minute. The water used in the four spray units shall be filtered and measured by means of a meter. The spray nozzles shall be regulated so as to deliver water at the rate of $2\frac{1}{2}$ gal. during the first 8 min. of the cycle. No water shall be used during the last 2 min. The cooling units shall be operated with a reciprocating motion so as to pass back and forth across the surface of the entire panel, including the dummy guard brick, 125 times in 10 min.

(*e*) The spalling treatment shall consist of 12 cycles, after which the furnace shall be shut off and the panels given two additional cooling cycles without the water mist.

(*f*) After carefully dismantling the panel, the kaolin shall be scraped off with a trowel, removing such pieces of the brick that separate easily. No attempt shall be made to separate pieces that might be removed by prying or tapping.

---

[1] See p. 796.

TENTATIVE DEFINITIONS OF TERMS RELATING TO REFRACTORIES[1]

A.S.T.M. Designation: C 71 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1934.

Silica Fire Clay.—A refractory mortar consisting of a finely ground mixture of quartzite, silica brick, and fire clay of various proportions.

Note.—Sometimes called silica cement by the trade.

Ground Fire Clay.—Fire clay or a mixture of fire clays which have been subjected to no treatment other than grinding or weathering, or both.

High-Temperature Bonding Mortar.—A mixture of refractory materials (such as fire clay, quartzite, chrome ore, magnesite, diaspore, or sillimanite minerals) either raw or calcined, to which other materials, not classified as refractories, have been added for the purpose of increasing the plasticity, giving air-setting properties, or lowering the temperature at which the bond develops.

---

[1] Under the standardization procedure of the Society, these definitions are under the jurisdiction of the A.S.T.M. Committee C-8 on Refractories.

These definitions, when adopted as standard, will be added to the Standard Definitions of Terms Relating to Refractories (A.S.T.M. Designation: C 71 – 31), 1933 Book of A.S.T.M. Standards, Part II, p. 189.

TENTATIVE SYMBOLS FOR HEAT TRANSMISSION[1]

A.S.T.M. Designation: C 108 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Terms ending "ivity" designate properties independent of size or shape, sometimes called "specific properties."

Examples: conductivity and resistivity.

Terms ending "ance" designate quantities depending not only on the material, but also upon size and shape, sometimes called "total quantities."

Examples: conductance and transmittance.

Terms ending "ion" designate rate of heat transfer.

Examples: conduction and transmission.

Heat Transmission Symbols

Area	A
Temperature, deg. Fahr. or deg. Cent	t
Temperature, deg. Fahr. absolute or deg. K (deg. Cent. absolute)	T
Length of path of heat flow (thickness)	L
Total quantity of heat transferred	Q
Time (when t is used for temperature)	τ
Thermal transmission (heat transferred per unit time)	q

$$q = \frac{Q}{\tau}$$

Thermal conductivity (heat transferred per unit time per unit area, and per degree per unit length)	k

$$k = \frac{\frac{q}{A}}{\frac{(t_1 - t_2)}{L}}$$

Thermal resistivity	$\frac{1}{k}$

---

[1] Under the standardization procedure of the Society, these symbols are under the jurisdiction of the A.S.T.M. Committee C-8 on Refractories.

These Symbols for Heat Transmission are those prepared jointly by the Committee on Heat Transmission of the National Research Council and the Subcommittee on Symbols for Heat and Thermodynamics of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations of the American Standards Association.

Thermal resistance (degrees, per unit of heat transferred per unit time)... R

$$R = \frac{t_1 - t_2}{q} = \frac{L}{kA}$$

Thermal conductance (heat transferred per unit time, per degree)........ C

$$C = \frac{1}{R} = \frac{kA}{L} = \frac{q}{t_1 - t_2}$$

Thermal conductance per unit area, sometimes called "Unit Conductance" (heat transferred per unit time per unit area, per degree)............ C_A

$$C_A = \frac{C}{A} = \frac{1}{RA} = \frac{q}{A\,(t_1 - t_2)} = \frac{k}{L}$$

Surface coefficient of heat transfer, Film coefficient of heat transfer, Individual coefficient of heat transfer (heat transferred per unit time per unit area, per degree).. h

$$h = \frac{\frac{q}{A}}{t_1 - t_2}$$

(In general h is not equal to $\frac{k}{L}$, where L is the actual thickness of the fluid film.)

Over-all coefficient of heat transfer, Thermal transmittance per unit area (heat transferred per unit time per unit area, per degree over-all).... U

$$U = \frac{\frac{q}{A}}{t_1 - t_2}$$

TENTATIVE SPECIFICATIONS
FOR
NON-REINFORCED CONCRETE SEWER PIPE[1]

A.S.T.M. Designation: C 14 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover non-reinforced concrete pipe intended to be used for the conveyance of sewage, industrial wastes and storm water.

Single Class

2. Pipes furnished under these specifications shall be of a single class to be designated "A.S.T.M. Non-Reinforced Concrete Sewer Pipe."

MATERIAL AND MANUFACTURE

Materials

3. (*a*) Concrete pipes shall be manufactured from portland-cement concrete.

(*b*) *Concrete.*—By concrete is meant a suitable mixture of portland cement, mineral aggregates and water, hardened by hydraulic chemical action.

(*c*) *Cement.*—Portland cement shall conform to the requirements of the Standard Specifications for Portland Cement (A.S.T.M. Designation: C 9) of the American Society for Testing Materials.[2]

(*d*) The materials shall possess such physical and chemical properties that when molded into pipe and properly cured, the product will be strong, durable, serviceable, free from objectionable defects, and shall conform to these specifications.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-13 on Concrete Pipe.

These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Cement-Concrete Sewer Pipe (A.S.T.M. Designation: C 14 - 24), 1933 Book of A.S.T.M. Standards, Part II, p. 207.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 3.

CHEMICAL TESTS AND REQUIREMENTS

Chemical Tests and Requirements

4. The purchaser may prescribe in advance special chemical requirements in cases where sewage, industrial wastes or ground waters have marked acid or alkaline character, or are of abnormally high temperatures. The purchaser may make use of chemical analysis of the pipe materials to ascertain whether these special requirements are met. The presence of deleterious materials causing slaking or disintegration shall be cause for rejection.

PHYSICAL PROPERTIES AND TESTS

Crushing Strength and Absorption

5. The crushing strength and absorption of non-reinforced concrete sewer pipe shall conform to the requirements given in Table I.

TABLE I.—PHYSICAL TEST REQUIREMENTS OF NON-REINFORCED CONCRETE SEWER PIPE.

NOTE.—For pipe 24 to 108 in. in internal diameter, see the Tentative Specifications for Reinforced-Concrete Sewer Pipe (A.S.T.M. Designation: C 75 - 34 T) of the American Society for Testing Materials.[1]

Internal Diameter, in.	Average Crushing Strength, lb. per linear foot		Maximum Absorption, per cent
	Three-Edge-Bearing Method[a]	Sand-Bearing Method[b]	
4	1000	1430	8
6	1000	1430	8
8	1000	1430	8
10	1100	1570	8
12	1200	1710	8
15	1370	1960	8
18	1540	2200	8
21	1810	2590	8
24	2150	3070	8

[a] See Section 12. [b] See Section 13.

The individual results of the various tests for each size of pipe and for each shipment class and plant shall be tabulated separately so as to show the percentage which fails to conform to the requirements of each test.

Hydrostatic Test

6. When subjected to the internal hydrostatic pressures specified in Section 20, the pipe shall show no leakage. Moisture appearing on the surface of the pipe in the form of patches or beads adhering to the surface shall not be considered leakage.

Test Specimens

7. (*a*) The specimens for purpose of tests shall be selected by the purchaser or his representative at the point or points designated by him when placing the order.

---

[1] See p. 822.

(*b*) The manufacturer or seller shall furnish specimens for test, without charge, up to 0.5 per cent of the number of pipes in each size of pipe furnished, except that in no case shall less than two specimens be furnished.

Measurement and Observation of Specimens

8. (*a*) The specimens of pipe shall be sound, full-size pipe. They shall first be freed from all visible moisture. When dry, each specimen shall be weighed, measured and inspected. The results of these observations shall be recorded and preserved on a report form as shown in Table IV.

(*b*) *Defective Specimens.*—Specimens which, when placed in a vertical position, do not give a metallic ring when struck with a hammer, or are observed to have cracks or other defects in form or dimensions in excess of the limits permitted in these specifications, shall be discarded and replaced with additional specimens from the shipment.

Crushing Strength Tests

Crushing Strength Tests

9. At the option of the purchaser, pipe shall be tested for crushing strength by either the three-edge-bearing method or by the sand-bearing method. Either of the two specified bearing methods shall be used on retests as provided for in Section 21 (*a*) and (*b*).

Number of Tests

10. The crushing strength test shall ordinarily be applied to not less than 75 per cent of the specimens received for purpose of tests.

Application of Load

11. (*a*) Any prime mover or hand power which will apply the load at a uniform rate of about 2000 lb. per minute, or in increments of not more than 100 lb. at the same rate, may be used in making the test.

(*b*) The center of the load shall be applied to the top bearing block at a point distant from the spigot end of the pipe equal to one-half of the over-all length of the pipe. The test load shall be applied to the upper bearing block in such a way as to leave the bearing free to move in a vertical plane passing midway between the lower bearings. In testing pipe that is "out of straight" the lines of the bearings chosen shall be from those which appear to give most favorable conditions for fair test.

(*c*) The pipe shall not be allowed to stand under load longer than is required to apply the load and to observe and record it.

(*d*) The testing machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part. The bearings shall be sufficiently rigid to transmit and receive uniform loads throughout their lengths without deflection, and shall be so attached to the machine as to transmit and receive the maximum stresses produced by the tests without lost motion, vibration or sudden shock.

(*e*) The bearings and the specimen shall be accurately centered so as to secure a symmetrical distribution of the loading on each side of the center of the pipe in every direction.

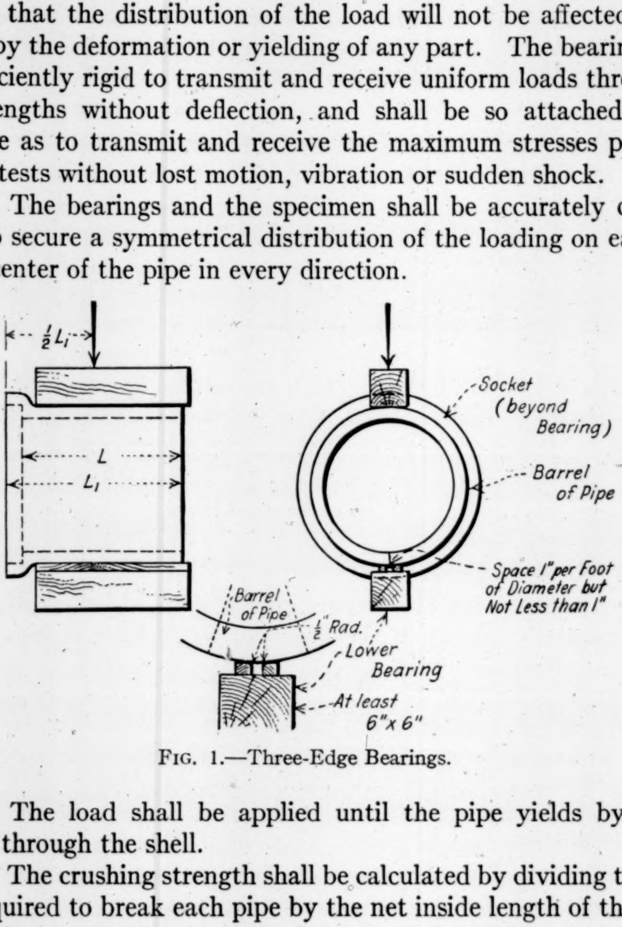


FIG. 1.—Three-Edge Bearings.

(*f*) The load shall be applied until the pipe yields by cracks passing through the shell.

(*g*) The crushing strength shall be calculated by dividing the total load required to break each pipe by the net inside length of the barrel of the pipe, measuring from the bottom of the socket to the end of the spigot.

Three-Edge-Bearing Method

12. When the three-edge-bearing method (see Fig. 1) is used, the ends of each specimen of pipe shall be accurately marked in halves of the circumference prior to the test. The two lower bearings shall consist of two wooden strips with vertical sides having their interior top corners rounded to a radius of approximately ½ in. The strips shall be straight and shall be securely fastened to a rigid block

at least 6 by 6 in. in cross-section. The interior vertical sides of the strips shall be parallel and a distance apart of 1 in. per foot of pipe diameter but in no case less than 1 in. If requested by the manufacturer or purchaser previous to the test, before the pipe is placed, a fillet of plaster of Paris and sand thick enough to compensate for the inequalities of the pipe barrel, shall be cast on the surface of the lower bearing. The pipe shall be placed upon the fillet while the plaster of Paris is still somewhat plastic. The upper bearing shall be a rigid wooden block at least 6 by 6 in. in cross-section, straight and true from end to end. A fillet of plaster of Paris may also be cast along the length of the crown of the pipe to equalize the bearing. The upper bearing shall be brought in contact while the plaster of Paris is still somewhat plastic. The upper and lower bearings shall extend the full length of the pipe exclusive of socket.

Sand-Bearing Method

13. When the sand-bearing method (see Fig. 2) is used the ends of each specimen of pipe shall be accurately marked in quarters of the circumference prior to the test. Specimens shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the pipe measured on the middle line of the barrel. The depth of bedding above and below the pipe at the thinnest points shall be one-half the radius of the middle line of the barrel.

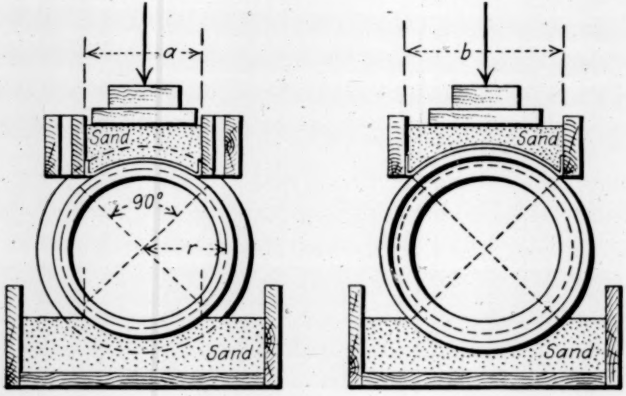
The sand used shall be clean and moist, and shall be such as will pass a 4760-micron (No. 4) sieve.[1]

The top bearing frame shall not be allowed to come in contact with the pipe nor with the top bearing plate. The upper surface of the sand in the top bearing shall be struck off level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate, in such a manner as to permit free motion of the plate in all directions. For this purpose a spherical bearing is preferred, but two rollers at right angles may be used. The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weights shall be piled symmetrically about a vertical line through the center of the pipe, and that the platform shall not be allowed to touch the top bearing frame.

---

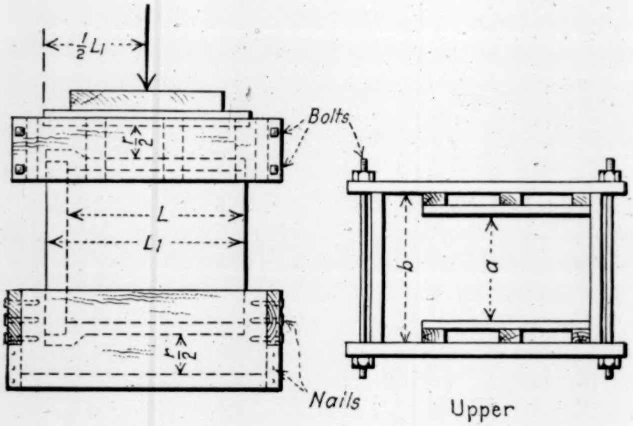
[1] For requirements for this sieve, see Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

The frames of the top and bottom bearings shall be made of timbers so heavy as to avoid appreciable bending by the side pressure of sand. The interior surfaces of the frames shall be dressed. No frame shall come in contact with the pipe during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the pipe.



Bedding of Barrel.

Bedding of Socket.



Side View.

Upper Bearing Frame.

FIG. 2.—Sand Bearings.

Absorption Test

Test Specimens

14. (*a*) The specimens shall be sound pieces, with all edges broken, and may be from pipes broken in the crushing strength tests. They shall be from 12 to 20 sq. in. in area, and shall be as nearly square as they can be readily prepared. They shall be free from observable cracks, fissures, laminations or shattered edges.

(*b*) *Identification.*—Each specimen shall be marked so that it may be identified with the pipe used in the crushing strength test from which the specimen was taken. The marking shall be applied so that the pigment used shall not cover more than 1 per cent of the total superficial area of the specimen.

Number of Tests

15. One specimen shall be tested of each pipe broken in the crushing strength test.

Weighing Apparatus

16. The balance used shall be sensitive to 0.5 g. when loaded with 1 kg., and weighings shall be read to the nearest 1 g. When other than metric weights are used, the same degree of accuracy shall be obtained.

Procedure

17. (*a*) *Drying.*—Preparatory to the absorption test, the specimen shall be first weighed and then dried in a drier or oven at a temperature of not less than 110 C. (230 F.) for not less than 3 hr. After removal from the drier, the specimen shall be allowed to cool in dry air to a temperature of 20 to 25 C. (68 to 77 F.), and then reweighed. If the specimen is comparatively dry when taken, and the second weight closely agrees with the first, it shall be considered dry. If the specimen is wet when taken it shall be placed in the drier for a drying treatment of 2 hr. and reweighed. If the third weight checks the second, the specimen shall be considered dry. In case of any doubt, the specimen shall be redried for 2-hr. periods, until check weights are obtained.

(*b*) *Immersion.*—The specimen, after final drying, cooling and weighing shall be placed with other similar specimens in a suitable wire receptacle, packed tightly enough to prevent jostling, covered with distilled water or rainwater, raised to the boiling point and boiled for 5 hr., and then cooled in water to a final temperature of 10 to 15 C. (50 to 59 F.).

(*c*) *Reweighing.*—The specimen shall be allowed to drain for 1 min., and the superficial moisture having been removed by towel or blotting paper, placed upon the balance and weighed.

Calculation and Reporting of Results

18. The absorption shall be calculated as percentage of the initial dry weight. The results shall be reported separately for each individual specimen together with the mean for all the specimens from the same shipment of pipe.

Hydrostatic Test

Number of Tests

19. Sound full-size pipe not exceeding about 25 per cent of the specimens received for purpose of tests in each size of pipe, shall be tested for leakage under internal hydrostatic pressure.

Hydrostatic Test

20. (*a*) The ends of the pipe shall be tightly closed by wooden or metallic bulkheads or covers faced with rubber or leather so that no leakage shall occur through the covers at the test pressure. One cover shall be provided with a $\frac{3}{4}$-in. wrought-iron nipple passing through the cover, and held securely in place and made water-tight by means of locknuts and washers or gaskets. The outer end of the nipple shall be connected with a pump discharge or water service line.

(*b*) Water pressures, as measured by a standardized gage attached to the delivery pipe close to the specimen, shall be internally applied to the specimen as follows:

5 lb. per sq. in. for 5 min.
10 lb. per sq. in. for 10 min.
15 lb. per sq. in. for 15 min.

ACCEPTANCE OR REJECTION ON RESULTS OF TESTS

Acceptance or Rejection

21. (*a*) Failure of 20 per cent of the specimens to meet the requirements of any of the tests specified in Sections 5 to 20 shall result in rejection of all the pipe in the shipment or delivery, corresponding to the sizes thus failing to comply; except that in the event of 20 per cent of the specimens in any size failing to meet the requirements, the manufacturer or seller may, with the consent of the purchaser, furnish for test, without charge, additional specimens from the same shipment to be selected as specified in Section 7. In case more than 80 per cent of the specimens tested, including those first tested, shall show substantial conformance for each of the various tests performed, then the entire shipment or delivery for this size shall be accepted; otherwise it shall be rejected.

(*b*) In addition to the requirements in Paragraph (*a*), failure of individual specimens tested to develop 75 per cent of the average crushing strength requirements shall be cause for rejection of the shipment, but the manufacturer or seller may cull the pipe and submit the balance of the shipment for retest, and if the shipment then conforms to all of the requirements of these specifications it shall be accepted.

TABLE II.—DIMENSIONS OF NON-REINFORCED CONCRETE SEWER PIPE.

NOTE.—For pipe 24 to 108 in. in internal diameter, see the Tentative Specifications for Reinforced-Concrete Sewer Pipe (A.S.T.M. Designation: C 75 - 34 T) of the American Society for Testing Materials.[1]

Internal Diameter (D), in.	Laying Length (L), ft.	Inside Diameter at Mouth of Socket (D_S), in.[a]	Depth of Socket (L_S), in.	Minimum Taper of Socket (H)	Thickness of Barrel (T), in.	Thickness of Socket (T_S)
4..............	2, $2\frac{1}{2}$, 3	6	$1\frac{1}{2}$	1:20	$\frac{9}{16}$	The thickness of the socket $\frac{1}{4}$ in. from its outer end shall be not less than three-fourths of the thickness of the barrel of the pipe.
6..............	2, $2\frac{1}{2}$, 3	$8\frac{1}{4}$	2	1:20	$\frac{5}{8}$	
8..............	2, $2\frac{1}{2}$, 3, 4	$10\frac{3}{4}$	$2\frac{1}{4}$	1:20	$\frac{3}{4}$	
10..............	2, $2\frac{1}{2}$, 3, 4	13	$2\frac{1}{2}$	1:20	$\frac{7}{8}$	
12..............	2, $2\frac{1}{2}$, 3, 4	$15\frac{1}{4}$	$2\frac{1}{2}$	1:20	1	
15..............	2, $2\frac{1}{2}$, 3, 4	$18\frac{3}{4}$	$2\frac{1}{2}$	1:20	$1\frac{1}{4}$	
18..............	2, $2\frac{1}{2}$, 3, 4	$22\frac{1}{4}$	$2\frac{3}{4}$	1:20	$1\frac{1}{2}$	
21..............	2, $2\frac{1}{2}$, 3, 4	26	$2\frac{3}{4}$	1:20	$1\frac{3}{4}$	
24..............	2, $2\frac{1}{2}$, 3, 4	$29\frac{1}{2}$	3	1:20	$2\frac{1}{8}$	

[a] When pipes are furnished having an increase in thickness over that given in last column, then the diameter of socket shall be increased by an amount equal to twice the increase of thickness of barrel.

TABLE III.—PERMISSIBLE VARIATIONS IN DIMENSIONS OF NON-REINFORCED CONCRETE SEWER PIPE.

NOTE.—For pipe 24 to 108 in. in internal diameter, see the Tentative Specifications for Reinforced-Concrete Sewer Pipe (A.S.T.M. Designation: C 75 - 34 T) of the American Society for Testing Materials.[1]

Nominal Size, Internal Diameter, in.	Limits of Permissible Variation in:				
	Length, in. per ft. (−)[a]	Internal Diameter, in.		Depth of Socket, in. (−)[a]	Thickness of Barrel, in. (−)[a]
		Spigot (±)[a]	Socket (±)[a]		
4...........................	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{16}$
6...........................	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{16}$
8...........................	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{16}$
10...........................	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{16}$
12...........................	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{16}$
15...........................	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{32}$
18...........................	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{32}$
21...........................	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{8}$
24...........................	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{8}$

[a] The minus sign (−) alone indicates that the plus variation is not limited; the plus and minus sign (±) indicates variation in both excess and deficiency in dimension.

---

[1] See p. 822.

A.S.T.M. SIZES, DIMENSIONS AND PERMISSIBLE VARIATIONS

Sizes and Dimensions

22. Pipes shall be furnished of the sizes, internal diameter, and with the dimensions given in Tables II and III. Where several lengths are mentioned in the table the purchaser shall indicate, at the time of purchase, which lengths shall be furnished; and unless so indicated, the manufacturer shall furnish such lengths as he may elect.

Permissible Variations

23. The permissible variation from the dimensions given in Table II shall not exceed those stated in Table III. Where the thickness of barrel is increased beyond that given in Table II in order to meet the specified requirements of strength, the diameter at inside of socket shall be increased by double the increase in thickness of barrel. Pipes intended to be straight shall not have variation in alignment of more than $\frac{1}{8}$ in. per foot of length.

WORKMANSHIP AND FINISH

Absence of Defects

24. Pipes shall be substantially free from fractures, large or deep cracks and blisters, laminations and surface roughness.

Finish of Ends

25. The ends of the pipes shall be square with their longitudinal axis.

Specials

26. (*a*) Special shapes shall have a plain spigot end and a socket end corresponding in all respects with the dimensions specified for pipes of the corresponding internal diameter. Branches shall be furnished to lay the same lengths as straight pipe. All specials shall conform in finish to the specifications for pipes given in Sections 24 and 25.

(*b*) Slants shall have their spigot ends cut at an angle of approximately 45 deg. with the longitudinal axis.

(*c*) Curves shall be at angles of 90, 45, $22\frac{1}{2}$ deg., as required. They shall conform substantially to the curvature specified.

(*d*) Branches shall be furnished with the connection or connections of the size or sizes specified, securely and completely fastened in the process of manufacture to the barrel of the pipe. T-branches and double T-branches shall have their axes perpendicular to the longitudinal axis of the pipe. Y-branches, double Y-branches, and V-branches shall have their axes approximately 45 deg. from the longitudinal axis of the pipe measured from the socket end. All branches shall terminate in sockets and the barrel of the branch shall be of sufficient length to permit making a proper joint when the connecting pipe is inserted in the branch socket.

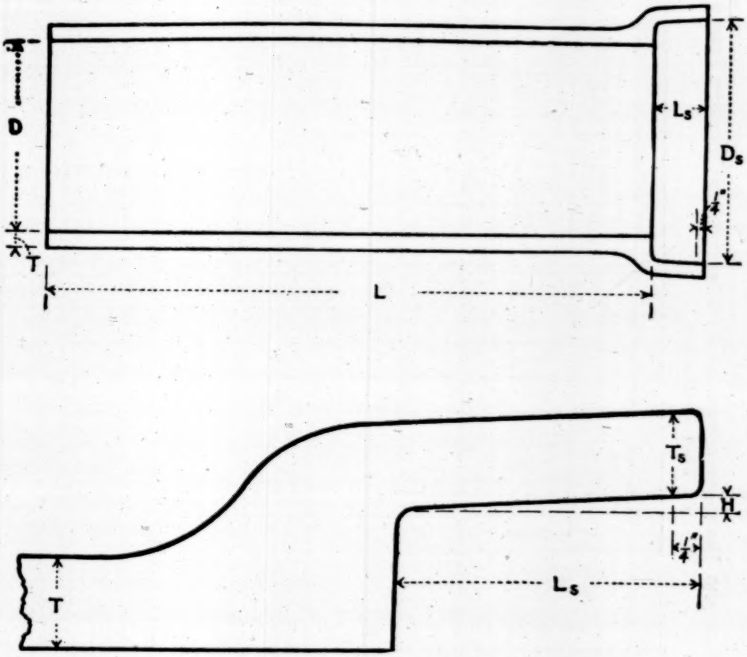


FIG. 3.—Application of Dimensions given in Table II.

(*e*) Channel or split pipe, curves and branches shall be accurate half sections of the corresponding size of pipe or other specials.

MARKING

Marking

27. Each length of pipe shall bear the initials or name of the person, company or corporation by whom manufactured, and the location of the plant. The markings shall be indented or stenciled on the exterior or interior of the barrel near the socket and shall be plainly legible for purpose of identification.

TABLE IV.—REPORT FORM FOR RECORDING DIMENSIONS, ETC., OF NON-REINFORCED-CONCRETE SEWER PIPE FURNISHED AS TEST SPECIMENS.

Specimen No.	Date.	Job No.	Material.	Manufacturer.	Location of Factory.	Nominal Size, in.	Weight, lb.	Length, ft.	Thickness of Spigot, in.				Thickness of Socket, in.				Internal Diameter, in.						Remarks.
																	Spigot		Back of Socket.		Socket.		
									Invert.	Crown.	Side.	Side.	Invert.	Crown.	Side.	Side.	Vertical.	Horizontal.	Vertical.	Horizontal.	Vertical.	Horizontal.	

INSPECTION AND REJECTION

Inspection

28. Each length of pipe shall be subject to inspection at the factory, trench or other point of delivery by a competent inspector employed by the consumer or purchaser. The purposes of the inspection shall be to cull and reject pipes which, independent of the physical tests herein specified, fail to conform to the requirements of these specifications.

Rejection

29. Pipes shall be subject to rejection on account of the following:

(*a*) Variations in any dimension exceeding the permissible variations given in Table III.

(*b*) Fracture or cracks passing through the shell or socket, except that a single crack at either end of a pipe not exceeding 2 in. in length or a single fracture in the socket not exceeding 3 in. in width nor 2 in. in length will not be deemed cause for rejection unless these defects exist in more than 5 per cent of the entire shipment or delivery.

(*c*) Blisters where the surface is broken or which project more than $\frac{1}{8}$ in. above the surface.

(*d*) Defects which indicate imperfect mixing and molding.

(*e*) Cracks sufficient to impair the strength, durability or serviceability of the pipe.

(*f*) Variation of more than $\frac{1}{8}$ in. per linear foot in alignment of pipe intended to be straight.

(*g*) Failure to give a clear ringing sound when placed on end and dry-tapped with a light hammer.

(*h*) Insecure attachment of branches on spurs.

Marking of Rejected Specimens

30. All rejected pipes shall be plainly marked by the inspector and shall be replaced by the manufacturer or seller with pipes which meet the requirements of these specifications, without additional cost to the purchaser.

TENTATIVE SPECIFICATIONS

FOR

REINFORCED-CONCRETE SEWER PIPE[1]

A.S.T.M. Designation: C 75 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1930; REVISED, 1934.

Scope. 1. These specifications cover reinforced-concrete pipe intended to be used for the conveyance of sewage, industrial wastes, and storm water.

Classes. 2. Pipe, under these specifications, shall be of two classes known respectively as "Standard Reinforced-Concrete Sewer Pipe" and "Extra-Strength Reinforced-Concrete Sewer Pipe."

Basis of Acceptance. 3. The acceptability of pipe shall be determined by the results of the strength tests specified in Sections 16 to 21, inclusive, if and when required, and by inspection to determine whether the pipe conforms to the specifications as to design and freedom from defects.

MATERIALS

Reinforced Concrete. 4. The reinforced concrete shall consist of portland cement, mineral aggregate and water in which steel has been embedded in such a manner that the steel and the concrete act together in resisting forces.

Cement. 5. Portland cement shall conform to the requirements of the Standard Specifications for Portland Cement (A.S.T.M. Designation: C 9) of the American Society for Testing Materials.[2]

Steel. 6. Reinforcement may consist either of wire which conforms to the requirements of the Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A.S.T.M. Designation: A 82),[3] or of bars which conform to the requirements of the Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A.S.T.M. Designation: A 15)[4] of the American Society for Testing Materials.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-13 on Concrete Pipe.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 3.

[3] 1934 Supplement to Book of A.S.T.M. Standards, p. 23.

[4] 1933 Book of A.S.T.M. Standards, Part I, p. 79.

7. (*a*) Fine aggregate shall consist of sand, stone screenings, or other inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, durable, uncoated grains and free from injurious amounts of dust, lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances. Fine aggregate shall be well graded and shall pass a ¼-in. screen.

Fine Aggregate.

TABLE I.—STANDARD REINFORCED-CONCRETE SEWER PIPE.

NOTE.—For pipe 4 to 24 in. in internal diameter, see the Tentative Specifications for Non-Reinforced Concrete Sewer Pipe (A.S.T.M. Designation: C 14 - 34 T) of the American Society for Testing Materials.[1]

Internal Diameter, in.	Strength Test Requirements, lb. per linear ft.				Minimum Design Requirements[a]					
	Three-Edge-Bearing Method		Sand-Bearing Method		Concrete, 3000 lb. per sq. in.		Concrete, 3500 lb. per sq. in.		Concrete, 4000 lb. per sq. in.	
	Load to Produce a 0.01-in. Crack	Ultimate Load	Load to Produce a 0.01-in. Crack	Ultimate Load	Shell Thickness, in.	Total Steel Area,[b] sq. in. per linear ft.	Shell Thickness, in.	Total Steel Area,[b] sq. in. per linear ft.	Shell Thickness, in.	Total Steel Area,[b] sq. in. per linear ft.
24	2400	3600	3600	5400	3	1 Line 0.06	2⅝	1 Line 0.08	2½	1 Line 0.09
27	2550	3800	3800	5700	3	1 " 0.07	2¾	1 " 0.10	2⅝	1 " 0.12
30	2700	4050	4050	6100	3½	1 " 0.09	3	1 " 0.12	2¾	1 " 0.14
33	2850	4300	4300	6400	3¾	1 " 0.11	3¼	1 " 0.14	2¾	1 " 0.17
36	3000	4500	4500	6750	4	2 Lines[c] totaling 0.14	3⅜	2 Lines[c] totaling 0.20	3	2 Lines[c] totaling 0.23
42	3200	4800	4800	7200	4½	2 " " 0.16	3¾	2 " " 0.23	3⅜	2 " " 0.27
48	3400	5100	5100	7650	5	2 " " 0.21	4¼	2 " " 0.27	3¾	2 " " 0.32
54	3700	5550	5550	8300	5½	2 " " 0.25	4⅝	2 " " 0.32	4¼	2 " " 0.38
60	4000	6000	6000	9000	6	2 " " 0.29	5	2 " " 0.38	4½	2 " " 0.44
66	4250	6350	6350	9550	6½	2 " " 0.32	5⅜	2 " " 0.44	4¾	2 " " 0.47
72	4500	6750	6750	10100	7	2 " " 0.36	5¾	2 " " 0.47	5	2 " " 0.55
78	....	....	....	....	7½	2 " " 0.40	...	....	...	....
84	....	....	....	....	8	2 " " 0.43	...	....	...	....
90	....	....	....	....	8	2 " " 0.49	...	....	...	....
96	....	....	....	....	8½	2 " " 0.57	...	....	...	....
108	....	....	....	....	9	2 " " 0.67	...	....	...	....

[a] The distance from the center line of the reinforcement to the nearest surface of the concrete has been assumed in the design tables as 1 in.

[b] The steel areas in this table are based on the use of cold-drawn steel wire with a value for *fs* of 27,500 lb. per sq. in. If reinforcing bars of billet steel of intermediate or hard grade are used the areas of steel given in this table shall be increased 37.5 per cent to conform to a value for *fs* of 20,000 lb. per sq. in. and if billet steel of structural grade is used the areas of steel given shall be increased 53 per cent to conform to a value for *fs* of 18,000 lb. per sq. in.

[c] Where two lines of steel are specified, a single line placed elliptically may be used, and the area of this shall be at least 50 per cent of the total steel area specified in the design table.

(*b*) Coarse aggregate shall consist of crushed stone, gravel, slag, or other approved inert materials with similar characteristics, or combinations thereof, having clean, hard, strong, durable, uncoated

Coarse Aggregate.

---

[1] See p. 809.

particles, free from injurious amounts of soft, friable, thin, elongated or laminated pieces, alkali, organic, or other deleterious matter.

Mixture. 8. The aggregates shall be so graded and proportioned and thoroughly mixed with such proportions of cement and water as will produce a homogeneous concrete mixture of such quality that the concrete will conform to the test and design requirements of these specifications.

TABLE II.—EXTRA-STRENGTH REINFORCED-CONCRETE SEWER PIPE.

NOTE.—For pipe 4 to 24 in. in internal diameter, see the Tentative Specifications for Non-Reinforced Concrete Sewer Pipe (A.S.T.M. Designation: C 14 – 34 T) of the American Society for Testing Materials.[1]

Internal Diameter of Pipe, in.	Strength Test Requirements, lb. per linear ft.				Minimum Design Requirements[a]			
	Three-Edge-Bearing Method		Sand-Bearing Method		Concrete, 4000 lb. per sq. in.		Concrete, 5000 lb. per sq. in.	
	Load to Produce a 0.01-in. Crack	Ultimate Load	Load to Produce a 0.01-in. Crack	Ultimate Load	Shell Thickness, in.	Total Steel Area,[b] sq. in. per linear ft.	Shell Thickness, in.	Total Steel Area,[b] sq. in. per linear ft.
24....	3000	4500	4500	6 750	3	1 Line 0.09	$2\frac{5}{8}$	1 Line 0.12
27....	3150	4700	4700	7 100	3	1 " 0.11	$2\frac{3}{4}$	1 " 0.13
30....	3300	4900	4900	7 400	$3\frac{1}{2}$	1 " 0.13	3	1 " 0.15
33....	3450	5200	5200	7 800	$3\frac{3}{4}$	1 " 0.14	$3\frac{1}{4}$	1 " 0.17
36....	3600	5400	5400	8 100	4	2 Lines[c] totaling 0.18	$3\frac{3}{8}$	2 Lines[c] totaling 0.23
42....	3900	5800	5800	8 800	$4\frac{1}{2}$	2 " " 0.20	$3\frac{3}{4}$	2 " " 0.27
48....	4200	6300	6300	9 450	5	2 " " 0.27	$4\frac{1}{4}$	2 " " 0.32
54....	4500	6700	6700	10 100	$5\frac{1}{2}$	2 " " 0.30	$4\frac{5}{8}$	2 " " 0.38
60....	4800	7200	7200	10 800	6	2 " " 0.34	5	2 " " 0.44
66....	4900	7350	7350	11 000	$6\frac{1}{2}$	2 " " 0.37	$5\frac{3}{8}$	2 " " 0.47
72....	5000	7500	7500	11 250	7	2 " " 0.43	$5\frac{3}{4}$	2 " " 0.55
78....	....	....	....	.....	$7\frac{1}{2}$	2 " " 0.47	...	....
84....	....	....	....	.....	8	2 " " 0.50	...	....
90....	....	....	....	.....	8	2 " " 0.60	...	....
96....	....	....	....	.....	$8\frac{1}{2}$	2 " " 0.68	...	....
108....	....	....	....	.....	9	2 " " 0.82	...	....

[a] The distance from the center line of the reinforcement to the nearest surface of the concrete has been assumed in the design tables as 1 in.

[b] The steel areas in this table are based on the use of cold-drawn steel wire with a value for f_s of 27,500 lb. per sq. in. If reinforcing bars of billet steel of intermediate or hard grade are used the areas of steel given in this table shall be increased 37.5 per cent to conform to a value for f_s of 20,000 lb. per sq. in. and if billet steel of structural grade is used the areas of steel given shall be increased 53 per cent to conform to a value for f_s of 18,000 lb. per sq. in.

[c] Where two lines of steel are specified, a single line placed elliptically may be used, and the area of this shall be at least 50 per cent of the total steel area specified in the design table.

DESIGN

Minimum Designs. 9. The shell thickness and the amount of circumferential reinforcement shall not be less than the minimum design requirements given in Tables I and II for the classes of pipe and the strength of concrete therein specified.

---

[1] See p. 809.

Joints.

10. The ends of reinforced concrete pipe shall be so formed that when the pipe are laid together and the joints cemented, they shall make a continuous and uniform line of pipe with a smooth and regular interior surface. The joints shall be of such design as will permit effective cementing to reduce leakage and infiltration to a satisfactory minimum and to permit placement without appreciable irregularities in the flow line.

Placing Reinforcement.

11. When two lines of reinforcement are used in circular pipe, one shall be placed near the inner and one near the outer surfaces of the pipe. When a single line of circular reinforcement is used in circular pipe, it shall be placed near the inner surface of the pipe shell. The single line of elliptical reinforcement used in circular pipe, or the single line of circular reinforcement in elliptical pipe shall be placed near the inner surface at the "top" and "bottom" of the pipe and near the outer surface at the sides (see Section 26 (*d*)).

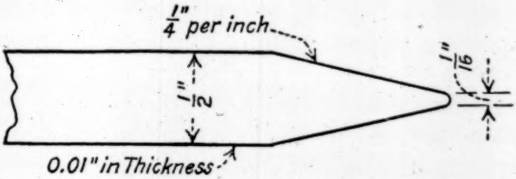


FIG. 1.—Gage Leaf for Measuring Cracks.

Longitudinals.

12. Each line of circumferential reinforcement shall be assembled into a cage and have sufficient longitudinal bars or members, extending through the barrel of the pipe, to afford rigidity and maintain the reinforcement in exact shape.

Laps and Welds.

13. The reinforcement shall be lapped not less than 30 diameters, or if welded, the joints shall develop the full strength of the reinforcement. The spacing center to center of adjacent rings of circumferential reinforcement in a cage shall not exceed 4 in. up to and including pipe 48 in. in diameter, nor exceed the shell thickness for larger pipe and shall in no case exceed 6 in.

PHYSICAL TEST REQUIREMENTS

Strength Requirements.

14. The ultimate load, as determined by either of the methods described in Section 20, shall not be less than the ultimate loads given in Tables I and II for the size and class of pipe being tested. When the test load reaches the cracking load given in Tables I and II for the size and class of pipe being tested, there shall be in the barrel of the pipe no crack having a surface width of 0.01 in. or more (see Note), for a length of 1 ft. or more. The ultimate load is reached when the pipe will sustain no greater load.

NOTE.—It is recommended that the width of the crack be measured by means of a gage made from a leaf 0.01 in. in thickness from a set of standard machinists' gages, ground to a point of 1/16 in. in width, with corners rounded, and with a taper of 1/4 in. per inch, as illustrated by Fig. 1. The crack shall be considered to be 0.01 in. in width when the point of the gage will just enter it at close intervals.

Elliptical Pipe.

15. Elliptical pipe shall conform to the test requirements for circular pipe having the same horizontal internal diameter.

PHYSICAL TESTS

Strength Tests and Inspection.

16. Pipe 24 to 72 in. in diameter shall be tested for strength as provided in Sections 18, 19 and 20, or the purchaser may elect to accept all pipe with respect to strength on the basis of cylinder tests of the concrete as provided in Section 21. When strength tests are required on pipe larger than 72 in. in diameter, the purchaser shall so specify in the order.

Specimen for Strength Test.

17. The specimens for the strength test shall be full size pipe which shall in every respect conform to the inspection requirements specified in Section 28.

Selection of Specimens for Strength.

18. The specimens to be tested for strength shall be representative and shall be selected by the purchaser or his representative at the point or points designated by him when placing the order. The manufacturer or seller shall furnish specimens for test, without charge, up to 0.5 per cent of the number of pipe in each size of pipe, 24 to 36 in., inclusive, furnished except that in no case shall less than two specimens be furnished. Should additional tests be made upon the demand of the purchaser or manufacturer, then cost of such additional test specimens and the expense of testing shall be borne by the party making such demand.

Complying with Strength Tests.

19. (*a*) Should the test specimens selected by the purchaser conform to the test requirements, then all pipe represented by such specimens shall be accepted as to strength, provided the pipe shall otherwise conform to the specifications.

(*b*) Should any of the specimens first tested fail to conform to the test requirements, then the manufacturer shall have the right to additional tests of the size or sizes of pipe which have failed. If the strength attained by a specimen is less than the strength required, in the amounts shown in the first column of the following table, additional tests shall be made upon pipe to the number specified below, for each pipe of deficient strength:

PERCENTAGE OF REQUIRED STRENGTH	NUMBER OF PIPE FOR RETEST
Less than 100 per cent and more than 90 per cent	2
" " 90 " " " " 80 "	3
" " 80 " " " " 70 "	4

If the additional pipe so tested all conform to the test requirements, then all pipe represented by such tests shall be accepted; otherwise they shall be rejected, unless other tests, mutually agreed upon between the purchaser and manufacturer, demonstrate to the satisfaction of the purchaser, the acceptability of the pipe. This latter provision, as to tests by agreement, shall also apply in the event that the strength attained by a pipe under test is less than 70 per cent of the required strength.

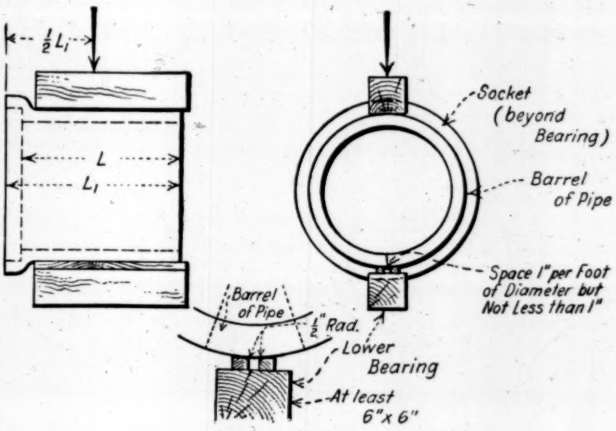

½ L₁
L
L₁
Socket (beyond Bearing)
Barrel of Pipe
Space 1" per Foot of Diameter but Not Less than 1"
Barrel of Pipe
½" Rad.
Lower Bearing
At least 6" x 6"

FIG. 2.—Three-Edge Bearings.

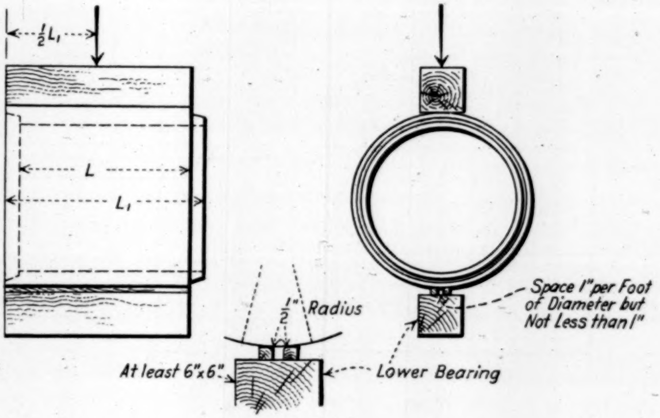
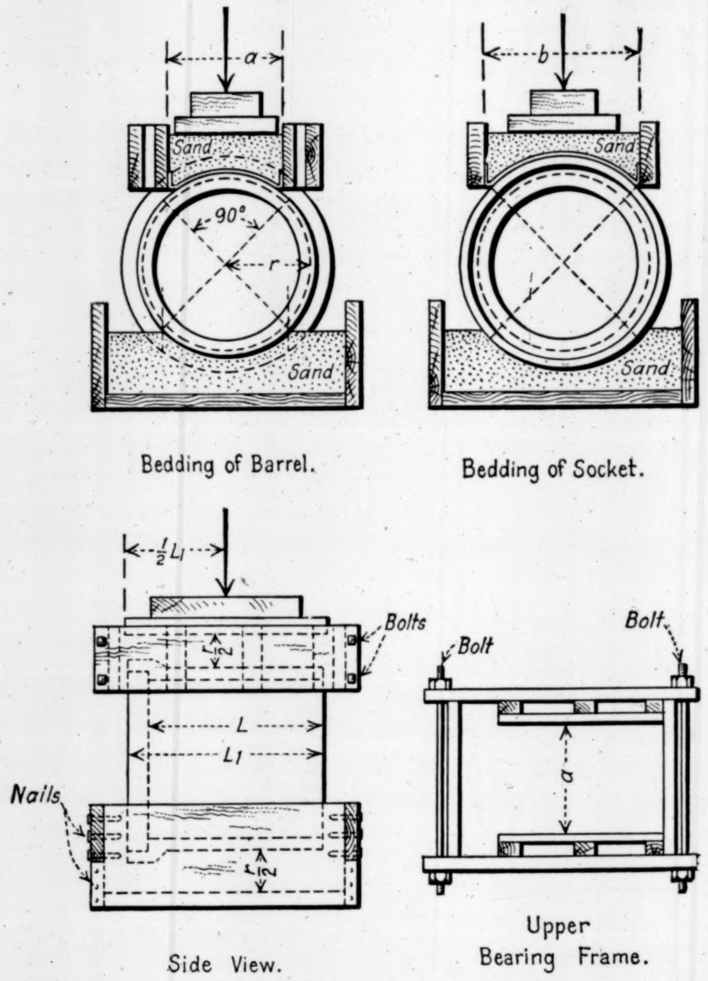

½ L₁
L
L₁
½" Radius
Space 1" per Foot of Diameter but Not Less than 1"
At least 6" x 6"
Lower Bearing

FIG. 3.—Three-Edge Bearings.

Strength Tests. 20. Pipe may be tested for strength by either the three-edge-ebaring or sand-bearing method.

Three-Edge-Bearing Method. (*a*) When the three-edge-bearing method is used (see Figs. 2 and 3) the ends of each specimen of pipe shall be accurately marked in halves of the circumference prior to the test. The two lower bearings shall consist of two wooden strips with vertical sides having their interior top corners rounded to a radius of approximately ½ in. The strips shall be straight and shall be securely fastened to a rigid block at least 6 by 6 in. in cross-section. The interior vertical sides of the strips shall be parallel and a distance apart of 1 in. per foot of pipe



Bedding of Barrel. Bedding of Socket.

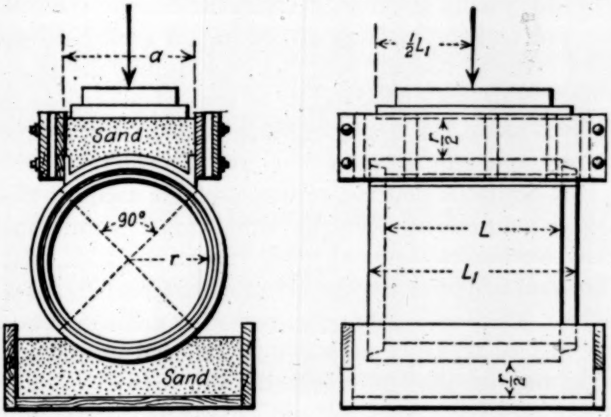
Side View. Upper Bearing Frame.

FIG. 4.—Sand Bearings.

diameter, but in no case less than 1 in. The upper bearing shall be a rigid wooden block at least 6 by 6 in. in cross-section, straight and true from end to end. The upper and lower bearings shall extend the full length of the pipe exclusive of bell. The pipe shall be placed symmetrically between the two bearings as illustrated in Figs. 2 and 3. In testing pipe which is "out of line," the lines of the bearings chosen shall be from those which appear to give the most favorable conditions for fair test.

Sand-Bearing Method.

(*b*) When the sand-bearing method is used (see Figs. 4 and 5), the ends of each specimen of pipe shall be accurately marked in quarters of the circumference prior to the test. Specimens shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the pipe measured on the middle line of the barrel. The depth of bedding above and below the pipe at the thinnest points shall be one-half the radius of the middle line of the barrel.



Bedding of Barrel.

FIG. 5.—Sand Bearings.

The sand used shall be clean and moist, and shall be such as will pass a 4760-micron (No. 4) sieve.[1] The sand in the lower bearing shall be loose when the pipe is placed.

The top bearing frame shall not be allowed to come in contact with the pipe nor with the top bearing plate. The upper surface of the sand in the top bearing shall be struck off level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate, or in such manner as to produce uniform deflection throughout the full length of the pipe. For this purpose a spherical bearing is preferred, but two rollers at right angles may be used. The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weights shall be piled symmetrically about a vertical line through the center of the pipe, and that the platform shall not be allowed to touch the top bearing frame.

---

[1] For requirements for this sieve, see the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

The frames of the top and bottom bearings shall be made of timbers so heavy as to avoid appreciable bending by the side pressure of sand. The interior surfaces of the frames shall be dressed. No frame shall come in contact with the pipe during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the pipe.

Testing Apparatus.

(*c*) It is desirable that the testing machine used for the strength tests shall give a uniform deflection throughout the full length of the pipe. Any mechanical or hand power device in which the head that applies the load moves at a speed of not more than 0.05 in. per minute or a machine which will apply the load at a uniform rate of 500 lb. per linear foot of pipe per minute may be used in making the test. The testing machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part. The load shall be applied continuously until the required strength of the pipe is reached.

Cylinder Tests and Reinforcement Examination.

21. The quality of the pipe may be determined by tests of the quality of concrete as placed in the pipe and examination of the quality, amount and accuracy of placement of the reinforcement. The quality of the concrete shall be determined on 6 by 12-in. test cylinders, taken from the concrete used in making the pipe and manufactured and cured under identical conditions with the pipe. Compression tests of these cylinders, determined in accordance with the Standard Methods of Making Compression Tests of Concrete (A.S.T.M. Designation: C 39) of the American Society for Testing Materials,[1] shall show an average strength of not less than the strength test requirements given in Tables I and II at 28 days and not less than 50 per cent of these strengths at 7 days, and not more than 10 per cent of the total number of cylinders tested shall show a strength of less than 80 per cent of these amounts. The position of the reinforcement shall conform to the requirements specified in Section 11.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 230.

22. Every manufacturer furnishing pipe under these specifications shall furnish all facilities necessary to carry out the tests required in these specifications. **Test Equipment.**

SIZE AND PERMISSIBLE VARIATIONS

23. Pipe of the internal diameters listed in Tables I and II shall be considered standard sizes. In elliptical pipe, the inside diameter at the minor axis shall be equal to the diameter of the corresponding size of circular pipe. **Standard Sizes.**

24. (*a*) Variations of the internal diameter shall not exceed 1.5 per cent for 24 to 36-in. pipe, inclusive, and 1 per cent for 42 to 108-in. pipe, inclusive. The shell thickness shall not be less than that given in Tables I and II by more than 5 per cent at any point. **Variations in Dimensions.**

(*b*) Variations in the position of the reinforcement cages shall not exceed ¼ in. for 24 to 33-in. pipe, inclusive, nor ½ in. for 36 to 108-in. pipe, inclusive, from the position provided in the design, nor shall the thickness of concrete over the reinforcement be less than ¾ in. at any point.

WORKMANSHIP AND FINISH

25. Pipe shall be substantially free from fractures, large or deep cracks and surface roughness. The planes of the ends of the pipe shall be perpendicular to their longitudinal axes. **Finish.**

MARKING

26. The following shall be clearly stenciled on each length of pipe: **Markings.**

(*a*) The pipe class { by an "S" for Standard Pipe; and
by an "X" for Extra-Strength Pipe;

(*b*) The date of manufacture;

(*c*) The name or trade-mark of the manufacturer;

(*d*) Elliptical pipe with circular reinforcing and circular pipe with elliptical reinforcing shall have the word "Top" or "Bottom" clearly stenciled on the inside of the pipe at the correct place to indicate the proper position when laid.

INSPECTION AND REJECTION

27. Pipe shall be considered ready for shipment when they conform to the test requirements, or when tests of 6 by 12-in. cylinders (Section 21) show that the concrete has attained the strength assumed in the design of the pipe. **Minimum Age for Shipment.**

28. All materials, processes of manufacture and finished pipe shall be subject to inspection and approval by an inspector employed by **Inspection.**

the purchaser. The manufacturer, when so directed by the inspector, shall have holes cut in such sections of the finished pipe (not exceeding one hole in every 50 sections delivered) as desired so that a proper inspection may be made of the quantity and placement of the reinforcement. If the pipes are tested for strength, inspection of the reinforcement may be made on the pipe used for those tests, and in no case shall the total number of pipe cut open for inspection of reinforcement exceed the number to which the purchaser is entitled under the provisions of Sections 18 and 19.

Causes for Rejection of Pipe.

29. Pipe shall be subject to rejection on account of failure to conform to any of the specification requirements or on account of any of the following:

(*a*) Fractures or cracks passing through the shell, except that an end crack that does not exceed the depth of the joint, or a fracture that at its deepest point does not exceed the depth of the joint nor extend more than 10 per cent around the circumference shall not be considered cause for rejection unless these defects exist in more than 5 per cent of the pipe inspected.

(*b*) Defects which indicate imperfect mixing, placing and curing concrete.

(*c*) Exposure of the reinforcement when such exposure would indicate that the reinforcement is misplaced.

TENTATIVE SPECIFICATIONS
FOR
SODIUM SILICATE FOR CURING CONCRETE[1]

A.S.T.M. Designation: C 111 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover sodium silicate to be applied to the surface of concrete for the purpose of preventing moisture loss during curing.

Properties and Tests

2. The sodium silicate shall have a density of not less than 42.25° Baumé at 60 F. (15.5 C.).

3. The ratio of sodium oxide, Na_2O, to silica, SiO_2, shall be 1 Na_2O to not less than 3.2 SiO_2.

Packing and Marking

4. The sodium silicate shall be delivered on the job in containers of suitable size and of a type which will not cause any deterioration of the product prior to its application to the concrete. The name of the manufacturer, the actual net weight, and the manufacturer's grade designation shall be plainly marked on each container.

Inspection and Sampling

5. Sodium silicate may be sampled for purpose of tests either at the plant prior to delivery or on the site of the work, at the option of the purchaser. At least one sample from each 500 gal. shall be taken to determine compliance with these specifications.

Rejection

6. The sodium silicate shall be rejected if it fails to meet any of the requirements of these specifications.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates.

TENTATIVE SPECIFICATIONS
FOR
CLASSIFICATION OF COALS BY RANK[1]

A.S.T.M. Designation: D 388 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1934.

Scope

1. These specifications cover the classification of coals by rank, that is, according to their degree of metamorphism, or progressive alteration, in the natural series from lignite to anthracite.

Basis of Classification

2. The basic scheme of classification is according to fixed carbon and calorific value (expressed in B.t.u.) calculated to the mineral-matter-free basis. The higher-rank coals are classified according to fixed carbon on the dry basis; and the lower-rank coals according to B.t.u. on the moist basis. Agglutinating and slacking indices are used to differentiate between certain adjacent groups.

Classification by Rank

Classification by Rank

3. (*a*) *Fixed Carbon and B.t.u.*—Coals shall be classified by rank in accordance with Table I. Coals having calorific values of 14,000 B.t.u. or more on the moist, mineral-matter-free basis, and coals having fixed carbon of 69 per cent or more on the dry, mineral-matter-free basis, shall be classified according to fixed carbon on the dry, mineral-matter-free basis; coals having calorific values less than 14,000 B.t.u. on the moist, mineral-matter-free basis shall be classified according to B.t.u. on the moist, mineral-matter-free basis, provided the fixed carbon on the dry, mineral-matter-free basis is less than 69 per cent.

(*b*) *Weathering Index.*—Coals showing average weathering indices of less than 5 per cent shall be considered non-weathering, coals showing average weathering indices of 5 per cent or more shall be considered weathering from the standpoint of classification.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the Sectional Committee on Classification of Coals functioning under the procedure of the American Standards Association with the American Society for Testing Materials as sponsor.

(*c*) *Agglutinating Index.*—Coals having average agglutinating indices of 500 g. or more at a ratio of 15 parts sand to 1 part coal shall be considered agglutinating from the standpoint of classification.

TABLE I.—CLASSIFICATION OF COALS BY RANK.

Legend: F.C. = Fixed Carbon. V.M. = Volatile Matter. B.t.u. = British thermal units.

Class	Group	Limits of Fixed Carbon or B.t.u. Mineral-Matter-Free Basis	Requisite Physical Properties
I. Anthracitic	1. Meta-anthracite	Dry F.C., 98 per cent or more (Dry V.M., 2 per cent or less)	
	2. Anthracite	Dry F.C., 92 per cent or more and less than 98 per cent (Dry V.M., 8 per cent or less and more than 2 per cent)	
	3. Semianthracite	Dry F.C., 86 per cent or more and less than 92 per cent (Dry V.M., 14 per cent or less and more than 8 per cent)	Non-agglutinating[a]
II. Bituminous[c]	1. Low volatile bituminous coal	Dry F.C., 77 per cent or more and less than 86 per cent (Dry V.M., 23 per cent or less and more than 14 per cent)	
	2. Medium volatile bituminous coal	Dry F.C., 69 per cent or more and less than 77 per cent (Dry V.M., 31 per cent or less and more than 23 per cent)	
	3. High volatile *A* bituminous coal	Dry F.C., less than 69 per cent (Dry V.M., more than 31 per cent); and moist[b] B.t.u., 14,000[d] or more	
	4. High volatile *B* bituminous coal	Moist[b] B.t.u., 13,000 or more and less than 14,000[d]	
	5. High volatile *C* bituminous coal	Moist B.t.u., 11,000 or more and less than 13,000[d]	Either agglutinating or non-weathering[e]
III. Subbituminous	1. Subbituminous *A* coal	Moist B.t.u., 11,000 or more and less than 13,000[d]	Both weathering and non-agglutinating
	2. Subbituminous *B* coal	Moist B.t.u., 9500 or more and less than 11,000[d]	
	3. Subbituminous *C* coal	Moist B.t.u., 8300 or more and less than 9500[d]	
IV. Lignitic	1. Lignite	Moist B.t.u., less than 8300	Consolidated
	2. Brown coal	Moist B.t.u., less than 8300	Unconsolidated

[a] If agglutinating, classify in low-volatile group of the bituminous class.

[b] Moist B.t.u. refers to coal containing its natural bed moisture but not including visible water on the surface of the coal.

[c] Pending the report of the Subcommittee on Origin and Composition and Methods of Analysis, it is recognized that there may be non-caking varieties in each group of the bituminous class.

[d] Coals having 69 per cent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of B.t.u.

[e] There are three varieties of coal in the High-volatile *C* bituminous coal group, namely, Variety 1, agglutinating and non-weathering; Variety 2, agglutinating and weathering; Variety 3, non-agglutinating and non-weathering.

Symbols for Expressing Classification

4. (*a*) The position of a coal in the scale of rank may be expressed in condensed form as in the following example:

$$(62 — 146)$$

in which the parenthesis signifies that the contained numbers are on the mineral-matter-free basis. The first number represents fixed carbon on the dry basis, reported to the nearest whole per cent. The second number represents B.t.u. on the moist basis, expressed as hundreds of B.t.u. (to the nearest hundred); for example, 14,580 B.t.u. would be represented as 146.

(*b*) When agglutinating or weathering properties enter into the classification of a coal, they shall be expressed outside and immediately following the parenthesis by the following symbols:

ag. = agglutinating
na. = non-agglutinating
we. = weathering
nw. = non-weathering.

(*c*) Symbols describing the grade of coal shall be placed after the parenthesis, as shown in the following illustration:

(62–146) 132–A8–F24–S1.6

The numbers in parenthesis are on the mineral-matter-free basis, and give the position of the coal in the scale of rank as explained in Paragraph (*a*) of this section. The numbers and symbols following the parenthesis show the position of the coal according to classification by grade as shown in Section 2 of the Tentative Specifications for Classification of Coals by Grade (A.S.T.M. Designation: D 389 – 34 T) of the American Society for Testing Materials.[1] That is, 132–A8–F24–S1.6 indicates a heating value of approximately 13,200 B.t.u., an ash content of 6.1 to 8.0 per cent, inclusive, an ash-softening temperature of 2400 to 2590 F., inclusive, and a sulfur content of 1.4 to 1.6 per cent, inclusive, all expressed on the basis of the coal as sampled.

SAMPLING

Bed Samples

5. (*a*) The classification of a coal bed, or part of a coal bed, in any locality shall be based on the average analysis and calorific value (and agglutinating and weathering index where required) of not less than three and preferably five or more face samples taken in different and uniformly distributed localities, either within the same mine or closely adjacent mines representing a continuous and compact area not greater than approximately four square miles in regions of geological uniformity. In regions where conditions indicate that the coal probably varies rapidly in short distances the spacing of samples and grouping of analyses to provide average values shall not be such that coals of obviously different rank will be used in calculating average values.

(*b*) The samples shall be taken in accordance with the U. S. Bureau of Mines method[2] or its equivalent, and shall be placed in moisture-tight containers in the mine.

---

[1] See p. 841.

[2] J. A. Holmes, "The Sampling of Coal in the Mine," U. S. Bureau of Mines *Technical Paper No. 1* (1918).

(*c*) Analyses of samples from outcrops or from weathered or oxidized coal shall not be used for classification by rank.

(*d*) In case the coal is likely to be classified on the "moist" basis, that is, containing the natural bed-moisture, the samples shall be taken at freshly exposed faces, which are free from visible surface moisture if possible. Samples of low-rank coals which appear dry at the time of collection frequently give off moisture which condenses on the inner surface of the sample containers, before they are opened for analysis. In the case of coals which were free from visible surface moisture when sampled, but which show moisture on the inner surface of the containers when opened, both the container and the coal shall be weighed before and after air-drying and the total loss in weight shall be reported as air-drying loss.

(*e*) If it is impossible to sample the coal without including visible surface moisture, and the coal is likely to be classified on the "moist" basis, the sampler shall include the following statement in the description: "Sample contains surface moisture." Samples so marked shall not be used for classification on a moist basis unless brought to a standard condition of moisture equilibrium at 30 C. in a vacuum desiccator containing a saturated solution of potassium sulfate (97 per cent humidity) as suggested by Stansfield and Gilbart.[1] Analyses of such wet samples which have been treated in this manner shall be designated as "wet samples equilibrated at 30 C. and 97 per cent humidity."

Tipple or Shipment Samples

6. (*a*) The classification of "run of mine" coal and prepared sizes of coal shall be based on representative samples taken in accordance with the Standard Method of Sampling Coal (A.S.T.M. Designation: D 21) of the American Society for Testing Materials.[2]

(*b*) In case the coal is likely to be classified on the "moist" basis, the samples shall be taken at the tipple or preparation plant and protected against loss of moisture as specified in Sections 8 and 9 of the Standard Method D 21. Samples which appear dry at the time of collection shall be handled in accordance with Section 5 (*d*) above to ensure correct determination of total air-drying loss. Samples which have visible surface moisture on the coal when sampled, and which are likely to be classified on the "moist" basis, shall be marked by the sampler, equilibrated, and the analyses designated in accordance with Section 5 (*e*) above.

---

[1] Edgar Stansfield and K. C. Gilbart, "Moisture Determination for Coal Classification," *Transactions*, Am. Inst. Mining and Metallurgical Engrs., Coal Division, p. 125 (1932).

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 318.

METHODS OF ANALYSIS AND TESTS

Laboratory Sampling and Analysis

7. The coal shall be prepared and analyzed in accordance with the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (A.S.T.M. Designation: D 271) of the American Society for Testing Materials.[1]

Weathering or Slacking Index

8. Pending the adoption of a method by the American Society for Testing Materials, the weathering or slacking characteristics of coals shall be determined by the U. S. Bureau of Mines method[2] modified with respect to the selection of a standard humidity. Briefly, the test consists of air-drying 500 to 1000 g. of approximately 1 to 1½ in. lumps at a temperature of 30 to 35 C. and a humidity of 30 to 35 per cent for a period of 24 hr. and then immersing the lumps in water for 1 hr.; the water then being drained off, and the sample again air-dried for 24 hr. The amount of disintegration is determined by sieving on an 8-in. wire-mesh sieve with 0.263-in. square openings, and weighing the quantity of coal passing (undersize) and that retained on (oversize) the sieve. The percentage of coal passing the sieve (undersize), after deducting a blank sieving test, is the weathering or slacking index of the coal.

Agglutinating Index

9. Pending consideration of an agglomeration test now being investigated, the agglutinating index shall be determined in accordance with the Proposed Method of Test for Agglutinating Value of Coal, published as information by the American Society for Testing Materials.[3]

CALCULATION TO MINERAL-MATTER-FREE BASIS

Calculation of Fixed Carbon and B.t.u.

10. (*a*) For classification of coal according to rank, fixed carbon and B.t.u. shall be calculated to the mineral-matter-free basis in accordance with either the Parr formulas[4] (1), (2) and (3) or the approximation formulas (4), (5) and (6) given below. In case of litigation the appropriate Parr formula shall be used.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 269.

[2] A. C. Fieldner, W. A. Selvig and W. H. Frederic, "Accelerated Laboratory Test for Determination of Slacking Characteristics of Coal," U. S. Bureau of Mines *Report of Investigations No. 3055* (1930).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part I (1934).

[4] S. W. Parr, "The Classification of Coal," *Bulletin No. 180*, Engineering Experiment Station, University of Illinois (1928).

Calculation from "moist" basis:

Parr Formulas:

$$\text{Dry, Mm-free F.C.} = \frac{\text{F.C.} - 0.15\text{S}}{100 - (\text{M} + 1.08\text{A} + 0.55\text{S})} \times 100 \qquad (1)$$

$$\text{Dry, Mm-free V.M.} = 100 - \text{Dry, Mm-free F.C.} \qquad (2)$$

$$\text{Moist, Mm-free B.t.u.} = \frac{\text{B.t.u.} - 50\text{S}}{100 - (1.08\text{A} + 0.55\text{S})} \times 100 \qquad (3)$$

NOTE.—The above formula for fixed carbon is derived from the Parr formula for volatile matter.

Approximation Formulas:

$$\text{Dry, Mm-free F.C.} = \frac{\text{F.C.}}{100 - (\text{M} + 1.1\text{A} + 0.1\text{S})} \times 100 \qquad (4)$$

$$\text{Dry, Mm-free V.M.} = 100 - \text{Dry, Mm-free F.C.} \qquad (5)$$

$$\text{Moist, Mm-free B.t.u.} = \frac{\text{B.t.u.}}{100 - (1.1\text{A} + 0.1\text{S})} \times 100 \qquad (6)$$

where:

Mm = mineral matter;
B.t.u. = British thermal units;
F.C. = percentage of fixed carbon;
V.M. = percentage of volatile matter;
M = percentage of moisture;
A = percentage of ash;
S = percentage of sulfur;

Moist refers to coal containing its natural bed moisture, but not including visible water on the surface of the coal. See Section 5 (*d*) and (*e*) and Section 6 (*b*) above.

Modification for Coals High in Carbonate

(*b*) In case of controversy, samples containing more than 1.0 per cent of carbon dioxide occurring as carbonates shall be either (1) crushed to pass through an 840-micron (No. 20) sieve and floated on a heavy liquid of such specific gravity as to reduce the carbon dioxide occurring as carbonate to 1.0 per cent or less on a dry basis, provided, however, that the recovery of float coal shall not be less than 75 per cent; or (2) shall be analyzed for mineral matter according to the Parr method[1] for coals with high calcium carbonate content. In case of litigation, method (1) shall be used.

---

[1] S. W. Parr, "Chemical Study of Illinois Coal," Illinois Coal Mining Investigations, State Geological Survey, Urbana, Ill., *Bulletin No. 3*, p. 35 (1916).

APPENDIX

PUBLISHED ANALYSES SUITABLE FOR COAL CLASSIFICATION

Only such published analyses as have been made in accordance with the standard methods of the American Society for Testing Materials shall be used in the classification of coal; and if classification is on the basis of moist B.t.u., then only those samples which have been taken and transported to the laboratory in such a manner as to preserve the true moisture content of the coal shall be used. In general, the principal sources of published analyses of samples suitable for coal classification are the publications of the U. S. Bureau of Mines, the U. S. Geological Survey, and the Canadian Department of Mines. Suitable analyses are published also by some of the State Surveys and some of the Provinces of Canada. However, it must be kept in mind that many of the bed sample analyses of the governmental organizations are from prospects in which the coal may have been altered by exposure. Such samples shall not be used for classification. Analyses published prior to 1904 are unlikely to represent the true moisture content of coal, and even after this date, analyses from sources other than governmental laboratories are not likely to be representative with respect to moisture.

In view of the importance of the fixed carbon determination in coal classification, special attention is called to the 1913 revision in this method by the American Chemical Society.[1] The new revision was substantially the same as that introduced by the U. S. Bureau of Mines[2] a few years earlier, as a result of finding large discrepancies between results of the Pittsburgh, Pa., and Washington, D. C., laboratories. A considerable number of analyses were made before it was discovered that the natural-gas burners at the Pittsburgh laboratory gave high results for fixed carbon.[3] For this reason, the fixed carbon results of the U. S. Geological Survey or U. S. Bureau of Mines analyses designated by Laboratory Nos. 5147 to 9120, inclusive, shall not be used for the classification of coal.

All analyses made by any laboratory prior to 1913 should be rejected unless there is positive evidence that the methods of analysis were essentially those adopted by the American Society for Testing Materials in 1913.

---

[1] Preliminary Report of the Committee on Coal Analysis of the American Society for Testing Materials and the American Chemical Society, *Journal of Industrial and Engineering Chemistry*, Vol. 5, p. 517 (1913); see also Report of Subcommittee IV on Volatile Matter, *Proceedings*, Am. Soc. Testing Mats., Vol. XIV, Part I, p. 424 (1914).

[2] A. C. Fieldner, "Notes on the Sampling and Analysis of Coal," U. S. Bureau of Mines *Technical Paper No. 76*, p. 16 (1914).

[3] N. W. Lord, J. A. Holmes, F. M. Stanton, A. C. Fieldner and S. Sanford, "Analyses of Coals in the United States," U. S. Bureau of Mines *Bulletin No. 22*, Part I, p. 28 (1913).

TENTATIVE SPECIFICATIONS
FOR
CLASSIFICATION OF COALS BY GRADE[1]

A.S.T.M. Designation: D 389 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1934.

Scope

1. These specifications cover the classification of coals according to quality, as determined by calorific value, ash and sulfur content, and ash-softening temperature. Other properties, such as resistance to breakage, screen size and caking properties are under consideration.

Table I.—Symbols for Grading Coal According to Ash, Softening Temperature of Ash, and Sulfur (Analyses Expressed on the Basis of the Coal as Sampled).

Ash[a]		Softening Temperature of Ash[b]		Sulfur[a]	
Symbol	Per cent, inclusive	Symbol	Deg. Fahr., inclusive	Symbol	Per cent, inclusive
A4	0.0 to 4.0	F28	2800 and higher	S0.7	0.0 to 0.7
A6	4.1 to 6.0	F26	2600 to 2790	S1.0	0.8 to 1.0
A8	6.1 to 8.0	F24	2400 to 2590	S1.3	1.1 to 1.3
A10	8.1 to 10.0	F22	2200 to 2390	S1.6	1.4 to 1.6
A12	10.1 to 12.0	F20	2000 to 2190	S2.0	1.7 to 2.0
A14	12.1 to 14.0	F20 minus	less than 2000	S3.0	2.1 to 3.0
A16	14.1 to 16.0			S5.0	3.1 to 5.0
A18	16.1 to 18.0			S5.0 plus	5.1 and higher
A20	18.1 to 20.0				
A20 plus	20.1 and higher				

[a] Ash and sulfur shall be reported to the nearest 0.1 per cent by dropping the second decimal figure when it is 0.01 to 0.04, inclusive, and by increasing the percentage by 0.1 per cent when the second decimal figure is 0.05 to 0.09, inclusive. For example, 4.85 to 4.94 per cent, inclusive, shall be considered to be 4.9 per cent.

[b] Ash-softening temperatures shall be reported to the nearest 10 F. For example, 2635 to 2644 F., inclusive, shall be considered to be 2640 F.

CLASSIFICATION BY GRADE

Classification by Grade

2. Analyses shall be expressed on the basis of the coal as sampled. The calorific value of a coal shall be expressed in hundreds of B.t.u. to the nearest hundred, for example, 13,150 to 13,249 B.t.u., inclusive, shall be expressed as 132. The ash, softening temperature of ash, and sulfur content shall be expressed by symbols in accordance with Table I. For example, a coal designated as 132–A8–F24–S1.6,

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the Sectional Committee on Classification of Coals functioning under the procedure of the American Standards Association with the American Society for Testing Materials as sponsor.

indicates a heating value of approximately 13,200 B.t.u., an ash content of 6.1 to 8.0 per cent, inclusive, an ash-softening temperature of 2400 to 2590 F., inclusive, and a sulfur content of 1.4 to 1.6 per cent, inclusive.

Symbols for Expressing Classification

3. In reporting grade designations, the calorific value shall be given first, followed by the symbols separated by dashes, in the order shown in the example given in Section 2.

4. When both rank and grade of a coal are reported, the grade designation shall follow the rank designation as shown in Section 4 of the Tentative Specifications for Classification of Coals by Rank (A.S.T.M. Designation: D 388 – 34 T) of the American Society for Testing Materials,[1] and as illustrated in the following example:

(62 – 146) 132–A8–F24–S1.6

The numbers in parenthesis are on the mineral-matter-free basis and give the position of the coal in the scale of rank. The first number represents fixed carbon on the dry, mineral-matter-free basis reported to the nearest whole per cent. For example, 61.5 to 62.4 per cent fixed carbon, inclusive, shall be expressed as 62. The second number represents B.t.u. on the moist, mineral-matter-free basis, expressed as hundreds of B.t.u. to the nearest hundred. The meaning of 132–A8–F24–S1.6 is explained in Section 2.

SAMPLING

Sampling

5. The coal shall be sampled to represent its condition as sold. Sampling shall be performed in accordance with the Standard Method of Sampling Coal (A.S.T.M. Designation: D 21) of the American Society for Testing Materials.[2]

METHODS OF ANALYSIS

Analysis

6. The coal shall be analyzed in accordance with the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (A.S.T.M. Designation: D 271) of the American Society for Testing Materials.[3] Analyses shall be expressed on the basis of the coal as sampled.

---

[1] See p. 834.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 318.

[3] *Ibid.*, p. 269.

TENTATIVE SPECIFICATIONS
FOR
CREOSOTE[1]

A.S.T.M. Designation: D 390 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover creosote for use in preservative treatment of timber, as defined in the Standard Definitions of Terms Relating to Timber Preservatives (A.S.T.M. Designation: D 324) of the American Society for Testing Materials.[2] The creosote shall be a distillate of coal-gas or coke-oven tar.

Properties

2. Creosote shall conform to the following requirements:

Water	not more than 3 per cent
Matter insoluble in benzol[a]	not more than 0.5 per cent
Specific gravity, 38 C./15.5 C	not less than 1.03
Distillation, based on water-free oil:	
Up to 210 C	not more than 5 per cent
Up to 235 C	not more than 25 per cent
Float test at 70 C. of residue above 355 C. if it exceeds 5 per cent	not more than 50 sec.
Coke residue	not more than 2 per cent

[a] Samples of oil taken from working tanks may show an increase in matter insoluble in benzol due to treating operations. Such increases, provided they do not exceed by 1 per cent the specification limits, should not serve to cause rejection of the oil for non-conformity with the specifications, if it can be shown that the original fresh oil was of specified quality.

NOTE.—Owing to the complexity of the chemical composition and physical properties of coal-tar creosote oil, and to the fact that some of the same compounds and properties which characterize coal-tar creosote are found in certain petroleum derivatives, determination of the purity of creosote oil is difficult. When there is not certain assurance that the oil is a pure product, the following tests will aid in arriving at an opinion as to its coal-tar origin:

(*1*) Fraction distilling between 210 and 235 C. is usually solid or contains some solids when cooled to 25 C.

(*2*) All of the fractions up to 315 C. contain tar acids in varying amounts, usually at least 1 per cent, calculated on the amount of the fraction tested.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-7 on Timber.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 503.

(3) The specific gravity of the fraction between 235 and 315 C. is usually not lower than 1.025 and the specific gravity of the fraction between 315 and 355 C. is usually not lower than 1.085 at 38 C. compared with water at 15.5 C. However, some pure coal-tar distillates fall slightly below these limits.

If the oil does not comply with at least one of the foregoing tests, it is undoubtedly not a pure coal-tar creosote.

Sampling and Methods of Testing

3. The sampling and properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*i*):

(*a*) *Sampling.*—Standard Methods of Sampling and Testing Creosote Oil (A.S.T.M. Designation: D 38).[1]

(*b*) *Water.*—Standard Method of Test for Water in Creosote Oil (A.S.T.M. Designation: D 370)[2] or as an alternate method, the Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95).[3]

(*c*) *Matter Insoluble in Benzol.*—Standard Methods of Test for Insoluble Matter in Creosote Oil (A.S.T.M. Designation: D 367).[4]

(*d*) *Specific Gravity.*—Standard Method of Test for Specific Gravity of Creosote Oil (A.S.T.M. Designation: D 368).[5]

(*e*) *Distillation.*—Standard Method of Test for Distillation of Creosote Oil (A.S.T.M. Designation: D 246).[6]

(*f*) *Specific Gravity of Fractions.*—Standard Method of Test for Specific Gravity, 38/15.5 C., of Creosote Fractions (A.S.T.M. Designation: D 369).[7]

(*g*) *Float Test of Residue.*—Standard Method of Float Test for Bituminous Materials (A.S.T.M. Designation: D 139).[8]

(*h*) *Coke Residue.*—Standard Method of Test for Coke Residue of Creosote Oil (A.S.T.M. Designation: D 168).[9]

(*i*) *Tar Acids.*—Methods for Determination of Tar Acids in Creosote Oil, Standard Method 26*a* (1923) of the American Wood Preservers' Association.[10]

(*j*) *Volume and Specific Gravity Correction.*—Standard Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke-Oven Tars) (A.S.T.M. Designation: D 347).[11]

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 470.

[2] *Ibid.*, p. 495.

[3] *Ibid.*, p. 891.

[4] *Ibid.*, p. 483.

[5] *Ibid.*, p. 486

[6] *Ibid.*, p. 477.

[7] *Ibid.*, p. 488.

[8] *Ibid.*, p. 958.

[9] *Ibid.*, p. 474.

[10] *Manual of Recommended Practice*, Am. Wood Preservers' Assn.

[11] 1933 Book of A.S.T.M. Standards, Part II, p. 491.

TENTATIVE SPECIFICATIONS
FOR
CREOSOTE COAL-TAR SOLUTION[1]

A.S.T.M. Designation: D 391 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover creosote coal-tar solution for use in preservative treatment of timber. The creosote coal-tar solution shall be a product of which at least 80 per cent shall be a distillate of coal-gas or coke-oven tar.

Properties

2. Creosote coal-tar solution shall conform to the following requirements:

Water	not more than 3 per cent
Matter insoluble in benzol[a]	not more than 2 per cent
Specific gravity, 38 C./15.5 C	not less than 1.05 nor more than 1.12
Distillation, based on water-free oil:	
Up to 210 C	not more than 5 per cent
Up to 235 C	not more than 25 per cent
Float test at 70 C. of residue above 355 C. if it exceeds 26 per cent	not more than 50 sec.
Coke residue	not more than 6 per cent

[a] Samples of oil taken from working tanks may show an increase in matter insoluble in benzol due to treating operations. Such increases, provided they do not exceed by 1 per cent the specification limits, should not serve to cause rejection of the oil for non-conformity with the specifications, if it can be shown that the original fresh oil was of specified quality.

NOTE.—Owing to the complexity of the chemical composition and physical properties of coal-tar creosote oil, and to the fact that some of the same compounds and properties which characterize coal-tar creosote are found in certain petroleum derivatives, determination of the purity of creosote oil is difficult. When there is not certain assurance that the oil is a pure product, the following tests will aid in arriving at an opinion as to its coal-tar origin:

(*1*) Fraction distilling between 210 and 235 C. is usually solid or contains some solids when cooled to 25 C.

(*2*) All of the fractions up to 315 C. contain tar acids in varying amounts, usually at least 1 per cent, calculated on the amount of the fraction tested.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-7 on Timber.

(3) The specific gravity of the fraction between 235 and 315 C. is usually not lower than 1.025 and the specific gravity of the fraction between 315 and 355 C. is usually not lower than 1.085 at 38 C. compared with water at 15.5 C. However, some pure coal-tar distillates fall slightly below these limits.

If the oil does not comply with at least one of the foregoing tests, it is undoubtedly not a pure coal-tar creosote.

Sampling and Methods of Testing

3. The sampling and properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*i*):

(*a*) *Sampling.*—Standard Methods of Sampling and Testing Creosote Oil (A.S.T.M. Designation: D 38).[1]

(*b*) *Water.*—Standard Method of Test for Water in Creosote Oil (A.S.T.M. Designation: D 370)[2] or as an alternate method, the Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (A.S.T.M. Designation: D 95).[3]

(*c*) *Matter Insoluble in Benzol.*—Standard Methods of Test for Insoluble Matter in Creosote Oil (A.S.T.M. Designation: D 367).[4]

(*d*) *Specific Gravity.*—Standard Method of Test for Specific Gravity of Creosote Oil (A.S.T.M. Designation: D 368).[5]

(*e*) *Distillation.*—Standard Method of Test for Distillation of Creosote Oil (A.S.T.M. Designation: D 246).[6]

(*f*) *Specific Gravity of Fractions.*—Standard Method of Test for Specific Gravity, 38/15.5 C., of Creosote Fractions (A.S.T.M. Designation: D 369).[7]

(*g*) *Float Test of Residue.*—Standard Method of Float Test for Bituminous Materials (A.S.T.M. Designation: D 139).[8]

(*h*) *Coke Residue.*—Standard Method of Test for Coke Residue of Creosote Oil (A.S.T.M. Designation: D 168).[9]

(*i*) *Tar Acids.*—Methods for Determination of Tar Acids in Creosote Oil, Standard Method 26*a* (1923) of the American Wood Preservers' Association.[10]

(*j*) *Volume and Specific Gravity Correction.*—Standard Volume and Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke-Oven Tars) (A.S.T.M. Designation: D 347).[11]

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 470.

[2] *Ibid.*, p. 495.

[3] *Ibid.*, p. 891.

[4] *Ibid.*, p. 483.

[5] *Ibid.*, p. 486

[6] *Ibid.*, p. 477.

[7] *Ibid.*, p. 488.

[8] *Ibid.*, p. 958.

[9] *Ibid.*, p. 474.

[10] *Manual of Recommended Practice*, Am. Wood Preservers' Assn.

[11] 1933 Book of A.S.T.M. Standards, Part II, p. 491.

TENTATIVE SPECIFICATIONS
FOR
TIMBER PILES[1]

A.S.T.M. Designation: D 25 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1915; ADOPTED, 1920; REISSUED AS TENTATIVE IN AMENDED FORM, 1930; REVISED, 1934.

Scope

1. These specifications cover requirements for round timber piles to be used untreated, or treated by standard preservatives. Where sawed timber is used as piling, such as heavy sheet piles, appropriate specifications should be selected from the Standard Specifications for Structural Wood Joist and Planks, Beams and Stringers, and Posts and Timbers (A.S.T.M. Designation: D 245) of the American Society for Testing Materials.[2]

Kinds of Wood

2. (*a*) The purchaser shall specify the kind or kinds of wood he desires to use, and shall designate the kinds he desires for preservative treatment. Commonly used species are cedars, chestnut, cypress, Douglas fir, larch, oaks, pines, spruces, and tamarack.

(*b*) Piles of different kinds of wood shall be delivered in separate lots.

Use Classification

3. Timber piles are classified in these specifications under three general divisions according to the use intended, as follows:

(*a*) *Class A*.—Class A piles are suitable for use in heavy railway bridges and trestles. The minimum diameter of butt assumes the use of load-bearing timber caps 14 in. in width.

(*b*) *Class B*.—Class B piles are suitable for use in docks, wharves, highway work and general construction. The minimum diameter of butt assumes the use of load-bearing timber caps 12 in. in width.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-7 on Timber.

These specifications are in effect a revision of the former Standard Specifications for Southern Yellow-Pine Piles and Poles to be Creosoted (A.S.T.M. Designation: D 25 – 20), which standard was accordingly discontinued in 1930.

The requirements of these specifications are in substantial agreement with the Specifications for Timber Piles adopted by the Committee on Wooden Bridges and Trestles of the American Railway Engineering Assn. (A.R.E.A. *Manual*, p. 469, 1929); and with the Specifications for Highway Bridges and Incidental Structures adopted by the American Association of State Highway Officials.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 347.

When timber caps are not used, as in the case of piles under masonry foundations, the sizes given for Class C piles are recommended.

(*c*) *Class C.*—Class C piles are suitable for use in foundations which will always be completely submerged, for coffer-dams, falsework, and sundry temporary work.

Class A Piles

General Quality

4. Except as hereinafter provided, all piles shall be free from any defects which may impair their strength or durability as piling, such as decay, red heart, splits in piles to be treated, or splits longer than the measured butt diameter of piles not to be treated, twist of grain exceeding one-half of the circumference in any 20 ft. of length, unsound knots, numerous knots or holes, or shake more than one-third of the diameter of the pile. Piles which have been scored for turpentine shall be accepted, provided such scar does not exceed 36 in., and provided the scoring is of recent date showing the scar to be entirely sound and free from insect damage.

Knots

5. Sound knots will be permitted, provided they are not in clusters. The diameter of a sound knot shall not be greater than one-third of the least diameter of the pile at the section where it occurs, and shall not exceed 4 in. for piles 50 ft. and under in length. For piles over 50 ft. in length, knots between the section at mid-length and the butt shall conform to the limitation prescribed for piling under 50 ft. Between mid-length and the tip, single knots up to 5 in. in diameter will be permitted, provided they do not exceed one-half the diameter of the pile at the section where they occur. The diameter of a knot shall be measured at right angles to the length of the pile.

General Requirements

6. (*a*) *Sound Timber.*—All piles shall be cut from sound, live trees, except that fire-killed, blight-killed, or wind-felled timber may be used if not attacked by decay or insects. Piles shall be cut above the ground swell.

(*b*) *Tip.*—The tip shall be sound.

(*c*) *Butt End.*—The butt end shall be sound except in cedar piles, which may have a pipe or stump rot hole not more than 1½ in. in diameter; and in chestnut, blight not deeper than ½ in.

Preservative Treatment

7. (*a*) Piles for use without preservative treatment shall have as little sapwood as possible, and when used in exposed work, the

diameter of the heartwood shall not be less than eight-tenths of the actual diameter of the pile at the butt.

(*b*) Piles for use with preservative treatment shall have no sapwood restrictions, but preferably shall contain as much sapwood as possible. In southern pine the sapwood thickness shall not be less than $1\frac{1}{2}$ in. and in Douglas fir and larch not less than 1 in. on the butt end.

(*c*) Piles shall be peeled of bark, including the inner skin, soon after cutting so that the piles are smooth and clean. Care shall be taken to remove as little sapwood as possible while peeling the bark. The sapwood shall not be injured by unnecessary axe cuts. These piles shall be designated as piles for treatment.

Dimensions and Permissible Variations

8. The diameter of a pile in cases where the tree is not exactly round shall be determined either by measuring the circumference and dividing the number of inches by 3.14, or by taking the average of the maximum and minimum diameters at the location specified.

Dimensions of Piles

9. It is recommended that the diameters of piles measured under the bark shall conform to the following requirements, subject to a permissible variation of $-\frac{1}{2}$ in. in any diameter in not more than 25 per cent of the pieces of that diameter:

Table I.—Class A Piles.

Length, ft.	Diameter 3 Ft. from Butt, in.		Diameter of Tip, in., minimum
	Minimum	Maximum	
Douglas Fir and Southern Pine Piles[a]			
Under 40	14	18	10
40 to 50	14	18	9
50 to 70	14	18	8
70 to 90	14	20	7
Over 90	14	20	6
Black Oak, Chestnut, Cypress, Pin Oak, Post or Burr Oak, Red Oak, White Oak, or Willow Oak Piles			
Under 30	14	18	10
30 to 40	14	18	9
Over 40	14	18	8
Cedar Piles			
Under 30	14	22	10
30 to 40	14	22	9
Over 40	14	22	8

[a] Where larch, lodge pole or Norway pine, spruce, or tamarack piles are specified, their dimensions shall correspond to those shown in this table.

Length

10. All piles shall be furnished on order cut to any of the following lengths: 16 to 40 ft. in multiples of 2 ft., and over 40 ft. in multiples of 5 ft. A variation of 6 in. in length shall be allowable, but the average length in any shipment shall be equal to, or greater than, the specified lengths. The length of each pile shall be legibly marked on the butt end with white or black paint.

Straightness

11. Piles shall be free from short or reversed bends, and free from crooks greater than one-half of the diameter of the pile at the middle of the bend. In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed 4 per cent of the length of the bend, or $2\frac{1}{2}$ in. A line drawn from the center of the butt end to the center of the tip shall lie within the body of the pile.

Workmanship and Finish

12. *Taper.*—Piles shall have a gradual taper from the point of butt measurement to the tip.

13. *Surface Finish.*—All knots and limbs shall be trimmed or smoothly cut flush with the surface of the pile. Butt and tip shall be sawed square with the axis of the pile, or tip may be tapered to a point not less than 4 in. in diameter if directed by the engineer in charge.

14. *Peeled Piles.*—No piece shall be considered as thoroughly peeled unless all of the rough bark and at least 80 per cent of the inner bark shall have been removed. In no case shall any piece of inner bark be over $\frac{3}{4}$ in. in width or over 8 in. in length, and there shall be 1 in. of clean wood surface between any two strips.

Class B Piles

General Quality

15. Except as hereinafter provided, all piles shall be free from any defects which may impair their strength or durability as piling, such as decay, red heart, splits in piles to be treated, or splits longer than the measured butt diameter of piles not to be treated, twist of grain exceeding one-half of the circumference in any 20 ft. of length, unsound knots, numerous knots or holes, or shake more than one-third of the diameter of the pile. Piles which have been scored for turpentine shall be accepted, provided such scar does not exceed 36 in., and provided the scoring is of recent date showing the scar to be entirely sound and free from insect damage.

Knots

16. Sound knots will be permitted, provided they are not in clusters. The diameter of a sound knot shall not be greater than one-third of the least diameter of the pile at the section where it occurs, and shall not exceed 4 in. for piles 50 ft. and under in length. For piles over 50 ft. in length, knots between the section at mid-length and the butt shall conform to the limitation prescribed for piling under 50 ft. Between mid-length and the tip, single knots up to 5 in. in diameter will be permitted, provided they do not exceed one-half the diameter of the pile at the section where they occur. The diameter of a knot shall be measured at right angles to the length of the pile.

General Requirements

17. (*a*) *Sound Timber.*—All piles shall be cut from sound, live trees, except that fire-killed, blight-killed, or wind-felled timber may be used if not attacked by decay or insects. Piles shall be cut above the ground swell.

(*b*) *Tip.*—The tip shall be sound.

(*c*) *Butt End.*—The butt end shall be sound except in cedar piles, which may have a pipe or stump rot hole not more than 1½ in. in diameter; and in chestnut, blight not deeper than ½ in.

Preservative Treatment

18. (*a*) Piles for use without preservative treatment shall have as little sapwood as possible, and when used in exposed work, the diameter of the heartwood shall not be less than eight-tenths of the actual diameter of the pile at the butt.

(*b*) Piles for use with preservative treatment shall have no sapwood restrictions, but preferably shall contain as much sapwood as possible. In southern pine the sapwood thickness shall not be less than 1½ in. and in Douglas fir and larch not less than 1 in. on the butt end.

(*c*) Piles shall be peeled of bark, including the inner skin, soon after cutting so that the piles are smooth and clean. Care shall be taken to remove as little sapwood as possible while peeling the bark. The sapwood shall not be injured by unnecessary axe cuts. These piles shall be designated as piles for treatment.

Dimensions and Permissible Variations

19. The diameter of a pile in cases where the tree is not exactly round shall be determined either by measuring the circumference and

dividing the number of inches by 3.14, or by taking the average of the maximum and minimum diameters at the location specified.

Dimensions of Piles

20. It is recommended that the diameters of piles measured under the bark shall conform to the following requirements, subject to a permissible variation of $-\frac{1}{2}$ in. in any diameter in not more than 25 per cent of the pieces of that diameter:

TABLE II.—CLASS B PILES.

Length, ft.	Diameter 3 Ft. from Butt, in.		Diameter of Tip, in., minimum
	Minimum	Maximum	
DOUGLAS FIR AND SOUTHERN PINE PILES[a]			
Under 40	12	20	8
40 to 50	12	20	7
50 to 70	13	20	7
70 to 90	13	20	6
Over 90	13	20	5
BLACK OAK, CHESTNUT, CYPRESS, PIN OAK, POST OR BURR OAK, RED OAK, WHITE OAK, OR WILLOW OAK PILES			
Under 30	12	18	8
30 to 40	13	20	8
Over 40	13	20	7
CEDAR PILES			
Under 30	12	22	8
30 to 40	13	22	8
Over 40	13	22	7

[a] Where larch, lodge pole or Norway pine, spruce, or tamarack piles are specified, their dimensions shall correspond to those shown in this table.

Length

21. All piles shall be furnished on order cut to any of the following lengths: 16 to 40 ft. in multiples of 2 ft., and over 40 ft. in multiples of 5 ft. A variation of 6 in. in length shall be allowable, but the average length in any shipment shall be equal to, or greater than, the specified lengths. The length of each pile shall be legibly marked on the butt end with white or black paint.

Straightness

22. Piles shall be free from short or reversed bends, and free from crooks greater than one-half of the diameter of the pile at the middle of the bend. In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed 4 per cent of the length of the bend, or $2\frac{1}{2}$ in. A line drawn from the center of

the butt end to the center of the tip shall lie within the body of the pile.

Workmanship and Finish

23. *Taper.*—Piles shall have a gradual taper from the point of butt measurement to the tip.

24. *Surface Finish.*—All knots and limbs shall be trimmed or smoothly cut flush with the surface of the pile. Butt and tip shall be sawed square with the axis of the pile, or tip may be tapered to a point not less than 4 in. in diameter if directed by the engineer in charge.

25. *Peeled Piles.*—No piece shall be considered as thoroughly peeled unless all of the rough bark and at least 80 per cent of the inner bark shall have been removed. In no case shall any piece of inner bark be over $\frac{3}{4}$ in. in width or over 8 in. in length, and there shall be 1 in. of clean wood surface between any two strips.

Class C Piles

General Quality

26. Class C piles may be of sound, live timber that will stand driving, and need not be peeled if they are to be used without preservative treatment. They shall be free from decay and other imperfections such as bad knots and shakes which will materially affect their strength. Piles which have been scored for turpentine shall be accepted, provided such scar does not exceed 36 in., and provided the scoring is of recent date showing the scar to be entirely sound and free from insect damage.

Preservative Treatment

27. (*a*) Piles for use without preservative treatment shall have as little sapwood as possible, and when used in exposed work, the diameter of the heartwood shall not be less than eight-tenths of the actual diameter of the pile at the butt.

(*b*) Piles for use with preservative treatment shall have no sapwood restrictions, but preferably shall contain as much sapwood as possible. In southern pine the sapwood thickness shall not be less than $1\frac{1}{2}$ in. and in Douglas fir and larch not less than 1 in. on the butt end.

(*c*) Piles shall be peeled of bark, including the inner skin, soon after cutting so that the piles are smooth and clean. Care shall be taken to remove as little sapwood as possible while peeling the bark. The sapwood shall not be injured by unnecessary axe cuts. These piles shall be designated as piles for treatment.

Dimensions and Permissible Variations

28. The diameter of a pile in cases where the tree is not exactly round shall be determined either by measuring the circumference and dividing the number of inches by 3.14, or by taking the average of the maximum and minimum diameters at the location specified.

Dimensions of Piles

29. It is recommended that the diameters of piles measured under the bark shall conform to the following requirements, subject to a permissible variation of $-\frac{1}{2}$ in. in any diameter in not more than 25 per cent of the pieces of that diameter:

TABLE III.—CLASS C PILES.

Length, ft.	Diameter 3 Ft. from Butt, in.		Diameter of Tip, in., minimum
	Minimum	Maximum	
DOUGLAS FIR AND SOUTHERN PINE PILES[a]			
Under 40[b]	12	20	8
40 to 50	12	20	6
50 to 70	12	20	6
70 to 90	12	20	6
Over 90	12	20	5
BLACK OAK, CHESTNUT, CYPRESS, PIN OAK, POST OR BURR OAK, RED OAK, WHITE OAK, OR WILLOW OAK PILES			
Under 30[b]	12	20	8
30 to 40	12	20	8
Over 40	12	20	6
CEDAR PILES			
Under 30[b]	12	22	8
30 to 40	12	22	8
Over 40	12	22	7

[a] Where larch, lodge pole or Norway pine, spruce, or tamarack piles are specified, their dimensions shall correspond to those shown in this table.

[b] In Class C piles, a minimum diameter of 10 in. may be specified for lengths of 20 ft. and under.

Length

30. All piles shall be furnished on order cut to any of the following lengths: 16 to 40 ft. in multiples of 2 ft., and over 40 ft. in multiples of 5 ft. A variation of 6 in. in length shall be allowable, but the average length in any shipment shall be equal to, or greater than, the specified lengths. The length of each pile shall be legibly marked on the butt end with white or black paint.

Straightness

31. Piles shall be free from short or reversed bends, and free from crooks greater than one-half of the diameter of the pile at the middle

of the bend. In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed 4 per cent of the length of the bend, or $2\frac{1}{2}$ in. A line drawn from the center of the butt end to the center of the tip shall lie within the body of the pile.

Workmanship and Finish

32. *Taper.*—Piles shall have a gradual taper from the point of butt measurement to the tip.

33. *Surface Finish.*—All knots and limbs shall be trimmed or smoothly cut flush with the surface of the pile. Butt and tip shall be sawed square with the axis of the pile, or tip may be tapered to a point not less than 4 in. in diameter if directed by the engineer in charge.

34. *Peeled Piles.*—No piece shall be considered as thoroughly peeled unless all of the rough bark and at least 80 per cent of the inner bark shall have been removed. In no case shall any piece of inner bark be over $\frac{3}{4}$ in. in width or over 8 in. in length, and there shall be 1 in. of clean wood surface between any two strips.

TENTATIVE SPECIFICATIONS
FOR
TITANIUM BARIUM PIGMENT[1]

A.S.T.M. Designation: D 382 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover titanium barium pigment in the dry form, also ground in oil to form a paste.

Composition

2. (*a*) *Dry Pigment.*—The dry pigment shall consist of titanium dioxide and barium sulfate (Note).

NOTE.—Satisfactory material consists of titanium dioxide and precipitated barium sulfate.

(*b*) *Paste.*—The paste shall be made by thoroughly grinding the specified pigment in linseed oil.

Properties and Tests

3. (*a*) The color, oil absorption and tinting strength, when specified, shall be at least equal to that of a sample mutually agreed upon by the buyer and seller.

(*b*) *Dry Pigment.*—The dry pigment shall conform to the following requirements:

	MAXIMUM	MINIMUM
Coarse particles (total residue retained on a No. 325 sieve[2]), per cent	1.0	....
Titanium dioxide, per cent	...	24.0
Total impurities, including moisture, per cent	1.0	....
Barium sulfate	remainder	remainder

(*c*) *Paste.*—The paste as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of

brushing consistency. It shall mix readily in all proportions without curdling, with linseed oil, turpentine, or volatile petroleum spirits, or any mixture of these substances.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-1 on Preservative Coatings for Structural Materials.

[2] **For determining coarse particles, sieves 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.**

The paste shall conform to the following requirements:

	MAXIMUM	MINIMUM
Pigment, per cent	....	82.0
Linseed oil, per cent	18.0	....
Moisture and other volatile matter, per cent	0.7	....
Coarse particles and skins (total residue retained on a No. 325 sieve[1]), per cent of the dry pigment	1.5	....

Number of Tests

4. One sample shall be taken at random from each lot of 1000 packages or fraction thereof. If the packages are of such size that 1000 packages amount to more than a carload, one sample shall be taken at random from each carload.

---

[1] For determining coarse particles, sieves 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

TENTATIVE SPECIFICATIONS
FOR
TITANIUM CALCIUM PIGMENT[1]

A.S.T.M. Designation: D 383 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover titanium calcium pigment in the dry form, also ground in oil to form a paste.

Composition

2. (*a*) *Dry Pigment.*—The dry pigment shall consist of titanium dioxide and anhydrous calcium sulfate.

(*b*) *Paste.*—The paste shall be made by thoroughly grinding the specified pigment in linseed oil.

Properties and Tests

3. (*a*) The color, oil absorption and tinting strength, when specified, shall be at least equal to that of a sample mutually agreed upon by the buyer and seller.

(*b*) *Dry Pigment.*—The dry pigment shall conform to the following requirements:

	MAXIMUM	MINIMUM
Coarse particles (total residue retained on a No. 325 sieve[2]), per cent	1.0	....
Titanium dioxide, per cent	...	28.0
Total impurities, including moisture, per cent	1.0	....
Anhydrous calcium sulfate	remainder	remainder

(*c*) *Paste.*—The paste as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of brushing consistency. It shall mix readily in all proportions without curdling, with linseed oil, turpentine, or volatile petroleum spirits, or any mixture of these substances.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-1 on Preservative Coatings for Structural Materials.

[2] For determining coarse particles, sieves 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

The paste shall conform to the following requirements:

	MAXIMUM	MINIMUM
Pigment, per cent	....	80.0
Linseed oil, per cent	20.0	....
Moisture and other volatile matter, per cent	0.7	....
Coarse particles and skins (total residue retained on a No. 325 sieve[1]), per cent of the dry pigment	1.5	....

Number of Tests

4. One sample shall be taken at random from each lot of 1000 packages or fraction thereof. If the packages are of such size that 1000 packages amount to more than a carload, one sample shall be taken at random from each carload.

---

[1] For determining coarse particles, sieves 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

TENTATIVE SPECIFICATIONS

FOR

TITANIUM DIOXIDE[1]

A.S.T.M. Designation: D 384 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1934.

Scope

1. These specifications cover titanium dioxide in the dry form, also ground in oil to form a paste.

Composition

2. (*a*) *Dry Pigment.*—The dry pigment shall consist of titanium dioxide and shall be free from adulteration.

(*b*) *Paste.*—The paste shall be made by thoroughly grinding the specified pigment in linseed oil.

Properties and Tests

3. (*a*) The color, oil absorption and tinting strength, when specified, shall be at least equal to that of a sample mutually agreed upon by the buyer and seller.

(*b*) *Dry Pigment.*—The dry pigment shall conform to the following requirements:

	Maximum	Minimum
Coarse particles (total residue retained on a No. 325 sieve[2]), per cent	1.0	....
Titanium dioxide, per cent	...	97.0
Moisture, per cent	0.5	....

(*c*) *Paste.*—The paste as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of brushing consistency. It shall mix readily in all proportions without curdling, with linseed oil, turpentine, or volatile petroleum spirits, or any mixture of these substances.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-1 on Preservative Coatings for Structural Materials.

[2] For determining coarse particles, sieves 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

The paste shall conform to the following requirements:

	Maximum	Minimum
Pigment, per cent	....	75.0
Linseed oil, per cent	25.0	....
Moisture and other volatile matter, per cent	0.7	....
Coarse particles and skins (total residue retained on a No. 325 sieve[1]), per cent of the dry pigment	1.5	....

Number of Tests

4. One sample shall be taken at random from each lot of 1000 packages or fraction thereof. If the packages are of such size that 1000 packages amount to more than a carload, one sample shall be taken at random from each carload.

---

[1] For determining coarse particles, sieves 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials. 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

TENTATIVE SPECIFICATIONS

FOR

HIGH ZINC SULFIDE LITHOPONE[1]

A.S.T.M. Designation: D 385 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover high zinc sulfide lithopone in the dry form, also ground in oil to form a paste.

Composition

2. (*a*) *Dry Pigment.*—The dry pigment shall consist of zinc sulfide and barium sulfate.

(*b*) *Paste.*—The paste shall be made by thoroughly grinding the specified pigment in linseed oil.

Properties and Tests

3. (*a*) The behavior on exposure to light, the ease of mixing and consistency with an approved test vehicle, color, brightness, tinting strength and hiding power shall be at least equal to a standard sample. The standard sample and testing methods shall be mutually agreed upon by the buyer and seller.

(*b*) *Dry Pigment.*—The dry pigment shall conform to the following requirements:

	MAXIMUM	MINIMUM
Coarse particles (total residue retained on a No. 325 sieve[2]), per cent	1.0	....
Zinc sulfide, per cent	...	45.0
Zinc oxide, per cent	1.0	....
Moisture, per cent	0.5	....
Barium sulfate	remainder	remainder

(*c*) *Paste.*—The paste as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of

brushing consistency. It shall mix readily in all proportions without curdling, with linseed oil, turpentine, or volatile petroleum spirits, or any mixture of these substances.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-1 on Preservative Coatings for Structural Materials.

[2] For determining coarse particles, sieves 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

The paste shall conform to the following requirements:

	MAXIMUM	MINIMUM
Pigment, per cent	....	76.0
Linseed oil, per cent	24.0	....
Moisture and other volatile matter, per cent	0.8	....
Coarse particles and skins (total residue retained on a No. 325 sieve[1]), per cent of the dry pigment	1.5	....

Number of Tests

4. One sample shall be taken at random from each lot of 1000 packages or fraction thereof. If the packages are of such size that 1000 packages amount to more than a carload, one sample shall be taken at random from each carload.

---

[1] For determining coarse particles, sieves 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

TENTATIVE SPECIFICATIONS

FOR

ZINC SULFIDE[1]

A.S.T.M. Designation: D 386 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These specifications cover pigment grade zinc sulfide in the dry form, also ground in oil to form a paste.

Composition

2. (*a*) *Dry Pigment.*—The dry pigment shall consist of zinc sulfide, within the limits described below, without the addition of any material other than that incident to the process of manufacture.

(*b*) *Paste.*—The paste shall be made by thoroughly grinding the specified pigment in linseed oil.

Properties and Tests

3. (*a*) The behavior on exposure to light, the ease of mixing and consistency with an approved test vehicle, color, brightness, tinting strength and hiding power shall be at least equal to a standard sample. The standard sample and testing methods shall be mutually agreed upon by the buyer and seller.

(*b*) *Dry Pigment.*—The dry pigment shall conform to the following requirements:

	MAXIMUM	MINIMUM
Coarse particles (total residue retained on a No. 325 sieve[2]), per cent	1.0	....
Zinc sulfide, per cent	...	95.0
Zinc oxide, per cent	1.0	....
Moisture, per cent	0.5	....

(*c*) *Paste.*—The paste as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of

brushing consistency. It shall mix readily in all proportions without curdling, with linseed oil, turpentine, or volatile petroleum spirits, or any mixture of these substances.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-1 on Preservative Coatings for Structural Materials.

[2] For determining coarse particles, sieves 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

The paste shall conform to the following requirements:

	MAXIMUM	MINIMUM
Pigment, per cent	....	76.0
Linseed oil, per cent	24.0	....
Moisture and other volatile matter, per cent	0.8	....
Coarse particles and skins (total residue retained on a No. 325 sieve[1]), per cent of the dry pigment	1.5	....

Number of Tests

4. One sample shall be taken at random from each lot of 1000 packages or fraction thereof. If the packages are of such size that 1000 packages amount to more than a carload, one sample shall be taken at random from each carload.

---

[1] For determining coarse particles, sieves 3 in. in diameter are recommended, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

TENTATIVE METHOD OF TEST
FOR
TINTING STRENGTH OF WHITE PIGMENTS OR WHITE PIGMENT PASTES[1]

A.S.T.M. Designation: D 332 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1931; Revised, 1934.

Scope

1. This method is intended for determining the tinting strength of white pigments or white pigment pastes and is best used for a comparison of standard and sample of the same type of white pigment.

APPARATUS

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Balance.*—Regulation laboratory balance.

(*b*) *Burettes.*—Standard 1-ml. burettes, graduated in 0.1 ml., (stop-cock controlled) or the apparatus known as the Brown burette, which consists of a small burette as just described but with a small reservoir. The tips of all burettes shall be ground optically flat.

(*c*) *Glass Mullers.*—Standard type glass mullers with a grinding face of from $2\frac{3}{4}$ to 3 in. in diameter. The face shall be free from blow-holes and other imperfections, and kept sharp by lightly grinding with No. 303 optical emery or its equivalent and turpentine.

(*d*) *Rubbing Surface.*—Lithographers' stones or ground plate glass slabs, the surface of which is kept sharp by lightly grinding with No. 303 optical emery or its equivalent and turpentine.

(*e*) *Glass or Celluloid Sheets.*—Sheets of flat glass or flexible celluloid for use in weighing out the oils and pastes.

(*f*) *Spatula.*—A flexible spatula having a 3-in. blade for mixing the oil and pigment.

(*g*) *Scraper.*—A French scraper or body glazing scraper for smoothing down the color daubs. The scraper shall have a blade that is about 3 or 4 in. in width with a good straight edge.

(*h*) *Panels.*—Bright tin or clear glass panels for use in observing color matches.

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-1 on Preservative Coatings for Structural Materials.

MATERIALS

Materials

3. The following materials will be required:

(*a*) *Standard Pigment or Paste.*—A standard white pigment or white pigment paste mutually agreed upon by the seller and purchaser.

(*b*) *Tinting Material.*—Either ultramarine blue or a very fine, low-strength, uniform black tinting material prepared from finest lampblack (Note 1). If desired, the tinting material, either ultramarine blue or black, may be prepared in the form of an oil paste (Note 2) ground fine and placed in small collapsible tubes.

NOTE 1.—It is advisable to prepare such a pigment from the finest lampblack and the finest precipitated calcium carbonate by intimate mixing of one part of the dry lampblack and six parts of the dry calcium carbonate until a uniform mixture is obtained which will give check results with several duplicate samples of a standard white pigment.

NOTE 2.—Recommended formulas for such a paste using ultramarine blue are as follows:

140 lb.	Ultramarine blue	70 lb.	Ultramarine blue
50 lb.	Poppy oil	27 lb.	Refined linseed oil
3 lb.	Calcium stearate	3 lb.	4-hr. cooked linseed oil (560 F.)
2 lb.	Castile soap		
½ lb.	Turpentine		

(*c*) *Oil.*—White refined linseed oil with an acid number of approximately 4. The use of bodied oils or varnish may be essential in some cases.

PROCEDURE

Tinting Strength, White Pigments

4. The tinting strength of white pigments shall be determined as follows:

(*a*) Weigh accurately 2 g. of the standard white pigment and a sufficient amount of the blue (or black) tinting material to produce a paste which will have a 20 per cent light reflection (Note 1) when mixed with the oil. Place these materials on the rubbing surface and add sufficient oil to produce a paste of medium consistency (Note 2). Use sheets of flat glass or flexible celluloid in weighing out the pigments, oils and pastes. For regular control work the use of the burette is recommended for measuring the oil used, instead of weighing, because of the simplicity, speed and tolerant accuracy of the burette. Be sure to allow sufficient time for the burette to drain to its true level. In case of doubt and dispute over any tint, or in the case of viscous oils, all portions shall be weighed. If desired, the tinting material may be added in the form of a paste and in this case the weighed quantity of paste is added to the mulled sample on the rubbing slab and thoroughly mixed with the spatula until no streaking is noticeable. Work the materials into a paste with the spatula and then rub up the paste with the glass muller. Use a stroke 3 to 4 in. in width, and from 12 to 15 in. in length. In counting rubs, one stroke up and one stroke back is considered one rub. Allow the muller to travel up one side and back the other side, twisting the muller slightly at the top and bottom of each half stroke to help work in the pigment. After each 25 rubs with the muller "pick up" the pigment with the spatula by scraping the face of the muller and gathering the paste on the slab into a daub. Continue the mulling until the paste is given 100 rubs.

NOTE 1.—The light reflection may be measured by the Marten's photometer or other suitable instrument or by comparison with a paste known to have the specified light reflection.

NOTE 2.—This consistency shall be such that the paste can just be thrown from the spatula by a gentle whipping motion of the hand or by the tapping of the spatula blade with the index finger.

(*b*) Treat 2 g. of the unknown sample of white pigment in exactly the same manner as prescribed in Paragraph (*a*) for the standard white pigment, using sufficient tinting material to produce a paste which will exactly match the standard paste. Use sufficient oil with the unknown sample of white pigment to produce a paste having approximately the same consistency as the standard paste. Give the sample 100 rubs. It will be necessary to prepare several 2-g. portions of the unknown sample of white pigment using various amounts of the tinting material until the color of the standard paste is exactly matched. To judge such a color match, place the unknown and standard samples in juxtaposition on the bright tin or clear glass panel. Make the daub of each sample about 1 in. in width and 2 in. in length and draw the scraper lightly over the pastes to even off the ridge and so present both daubs on an even plane. If glass is used observe the rub-outs from the top and not through the glass panel.

Calculation

5. The tinting strength of the unknown sample shall be calculated from the following formula:

$$\text{Tinting strength of pigment} = \frac{\text{Wt., in grams, of tinting material used with unknown sample}}{\text{Wt., in grams, of tinting material used with standard sample}} \times T$$

where T = the empirical tinting strength value given to the standard white pigment.

Optional Procedure

6. (*a*) It is recognized that for routine grading of materials, use of equal consistencies, and working to a constant 20 per cent light reflection constitutes a refinement that is unnecessary. The following optional procedure for determining tinting strength of white pigments is recommended where routine analysis of similar pigments is being made. In case of any dispute or question, or where fine differences in tinting strength are to be measured using different types of pigments, only the procedure described in Section 4 shall be used.

(*b*) Weighed amounts of pigment and tinting material and measured amounts of oil as shown in the following table shall be used for preparing a smooth paste:

Pigment	Weight of Pigment, g.	Amount of Oil, ml.	Weight of Tinting Material, g.	
			Ultramarine Blue	Lampblack
White lead	2	0.4	0.2	0.04
Zinc oxide	2	0.6	0.2	0.04
35 per cent Leaded zinc oxide	2	0.4	0.2	0.04
Lithopone	2	0.5	0.2	0.04
Extra strength lithopone	2	0.5	0.2	0.04
Zinc sulfide	2	0.6	0.4	0.08
Titanium-barium pigment	2	0.5	0.2	0.04
Titanium-calcium pigment	2	0.5	0.2	0.04
Titanium dioxide	2	0.9	0.4	0.08

(*c*) The materials shall be worked into a paste and the paste then given 100 rubs with the glass muller, picking the paste up after each 25 mulls. Various amounts of the tinting material shall be rubbed up with other portions of the standard white pigment to give a series of standards. The unknown sample of white pigment shall be treated in exactly the same way as the standard sample, using the amount of tinting material and of oil shown in the table in Paragraph (*b*) and compared with the series of rub-outs of the standard pigment. The quality of tint shall be judged by placing the rub-outs in juxtaposition on the tin or glass panel as in the procedure described in Section 4 (*b*).

Calculation

7. The tinting strength of the unknown sample shall be calculated as follows: The ratio of the amount of tinting material used with the standard sample to give equality of light reflection or tint to the amount of tinting material used with the unknown sample multiplied by 100 is the tinting strength of the unknown sample.

Tinting Strength, Pastes

8. When the sample is in paste form, the tinting material should also preferably be in the form of an oil paste. The weighed quantity of tinting material in paste form shall be added to the weighed sample of white pigment paste on the rubbing slab and thoroughly mixed with the spatula until no streaking is noticeable. The tinting strength shall then be determined in accordance with the procedure described in Section 4 (*b*) and the calculation made as in Section 5. If desired, the optional procedure in Section 6 (*c*) may be used and the calculation made as in Section 7.

TENTATIVE METHODS OF TEST

FOR

MASS COLOR AND TINTING STRENGTH OF DRY COLOR PIGMENTS OR PASTES[1]

A.S.T.M. Designation: D 387 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These methods are intended for determining the mass color and tinting strength of the materials generally known as dry colors, either in the form of dry pigments or in the form of pastes in oil or Japan. They do not apply to the white pigments.

APPARATUS

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Balance.*—Regulation laboratory balance.

(*b*) *Burettes.*—Standard 1-ml. burettes, graduated in 0.1 ml., (stop-cock controlled) or the apparatus known as the Brown burette, which consists of a small burette as just described but with a small reservoir. The tips of all burettes shall be ground optically flat.

(*c*) *Glass Mullers.*—Standard type glass mullers with a grinding face of from $2\frac{3}{4}$ to 3 in. in diameter. The face shall be free from blow-holes and other imperfections, and kept sharp by lightly grinding with No. 303 optical emery or its equivalent and turpentine.

(*d*) *Rubbing Surface.*—Lithographers' stones or ground plate glass slabs, the surface of which is kept sharp by lightly grinding with No. 303 optical emery or its equivalent and turpentine. To guard against contamination, different slabs or stones should be available for red, yellow, blue, green and black pigments.

(*e*) *Glass or Celluloid Sheets.*—Sheets of flat glass or flexible celluloid for use in weighing out the samples of dry colors, oils and pastes.

(*f*) *Spatula.*—A flexible spatula having a 3-in. blade for mixing the oil and pigment.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-1 on Preservative Coatings for Structural Materials.

(*g*) *Scraper.*—A French scraper or body glazing scraper for smoothing down the color daubs placed on the glass or tin panels. The scraper shall have a blade that is about 3 or 4 in. in width with a good straight edge.

(*h*) *Panels.*—Bright tin or clear glass panels for use in observing color matches.

MATERIALS

Materials

3. The following materials will be required:

(*a*) *Standard Pigment or Paste.*—A standard pigment (dry color) or paste color in oil or Japan mutually agreed upon by the seller and purchaser.

(*b*) *Reduction Paste.*—Zinc oxide oil paste for tinting strength test (Note).

NOTE.—Recommended formulas for such a paste are as follows:

No. 1[a]	300 lb.	Green seal zinc oxide
	64 lb.	Poppy oil
	2 lb.	Calcium stearate
	1 lb.	Turpentine
No. 2[b]	90 lb.	Green seal zinc oxide
	10 lb.	Refined linseed oil
	1 lb.	4-hr. cooked linseed oil (560 F.)

---

[a] This formula yields a short paste, handy to use and which has little tendency to settle. The paste should be ground fine and placed in small collapsible tubes.

[b] This formula yields a paste that is slightly stringier than No. 1 and settles very little. New oil pastes should be prepared at least once each month. The paste should be ground fine and placed in small collapsible tubes.

(*c*) *Oil.*—White refined linseed oil with an acid number of approximately 4. In special cases, other oils may be essential, for example, earth colors may require raw oil, or pigments for printing inks require transparent lithographic varnish. Such special oils should be arranged for by the seller and purchaser.

PROCEDURE

Mass Color

4. Mass color shall be determined as follows:

(*a*) Carefully weigh the sample of pigment to be tested and counterbalance with the standard pigment. For regular control work the use of the burette is recommended for measuring the oil used, instead of weighing, because of the simplicity, speed and tolerant accuracy of the burette. In case of doubt and dispute over any color, or in the case of viscous oils, all portions shall be weighed. If oil is to be weighed, add oil to the dry samples accurately. Transfer the oil and pigment to the rubbing slab. If oil is to be measured, transfer the weighed samples of the pigments to the slab and add oil by dropping (slowly) from the burette, working up the paste with the small spatula. Be sure to allow sufficient time for the burette to drain to its true level. When all the dry pigment is worked up by means of the spatula, rub up the paste with the glass muller. Use a stroke from 3 to 4 in. in width and from 12 to 15 in. in length. In counting rubs given a color, one stroke up and one stroke back is considered one rub. Allow the muller to travel up one side and back the other side, twisting the muller slightly at the top and bottom of each half stroke to help work in the pigment. After the number of rubs with the muller, as specified in the following table, depending on the type of pigment, "pick up" the paste with the spatula by scraping the face of the muller and gathering the paste on the slab into a daub. Continue the mulling until the paste is given the specified number of rubs:

TOTAL NUMBER OF RUBS REQUIRED FOR PIGMENT	PICK-UP REQUIRED
300	after each 50 rubs
200	after each 40 rubs
100	after each 25 rubs
50	after each 15 rubs

(*b*) When the mulling is completed, place the unknown and standard samples in juxtaposition on the bright tin or clear glass panel. Make the daub of each sample about 1 in. in width and 2 in. in length and draw the scraper lightly over the pastes to even off the ridges and so present both daubs on an even plane. Mass tone should be judged immediately. If glass is used observe the rub-outs from the top and not through the glass panel. Observation for floating, bronzing, etc., shall be taken note of after 2 or 3 hr., if this fact is important to the purchaser. A pigment shall be considered as passing this test when its mass color is the same as that of the mutually agreed upon standard.

Tinting Strength, Color Pigments

5. The tinting strength of color pigments shall be determined as follows:

(*a*) Weigh the required amount of the mulled color paste from the slab and counterbalance with the standard pigment. Then add the correct amount of the "Reduction Paste" (zinc oxide oil paste) to the unknown and standard samples. Thoroughly mix each of the pastes on the flat glass or flexible celluloid sheets and transfer samples to the slab, mixing them thoroughly with spatula only, till no more streaking is noticeable.

(*b*) Place the unknown and standard samples in juxtaposition on the bright tin or clear glass panel. Make the daub of each sample at least 1 in. in width and about 2 in. in length and draw the scraper lightly over the pastes to even off the ridge and so present both daubs on an even plane. Judge the color immediately. If glass is used, observe the rub-outs from the top and not through the glass panel. If the sample shows the same character of tint and the rub-out is as dark or darker than the standard, it meets this test for tinting strength.

NOTE 1.—The following pigment rub-out scheme is outlined for the convenience of the operator. Because of the difference in oil absorption of similar pigments made by different manufacturers, the pigment rub-out scheme can necessarily serve only as a guide in the work.

PIGMENT RUB-OUT SCHEME

COLOR OR CLASS	AMOUNT OF COLOR, G.	VOLUME OF OIL, ML.	MULLS OR RUBS	REDUCTION, GRAMS OF REDUCTION PASTE TO GRAMS OF MULLED PASTE
C. P. Iron blues	1.0	0.80	300	5 to 0.1
C. P. Light and medium para toners	0.5	0.80	200	5 to 0.1
C. P. Dark para toners	0.6	0.80	300	5 to 0.1
10 per cent Para toners on whiting	1.0	0.50	50	2 to 0.1
C. P. Toluidine	0.5	0.50	150	5 to 0.1
C. P. Light chrome green	1.0	0.40	100	2 to 0.1
C. P. Medium chrome green	1.0	0.50	150	2 to 0.1
C. P. Deep chrome green	1.0	0.60	200	2 to 0.1
25 per cent Grinder's green, light	1.0	0.30	50	2 to 0.1
25 per cent Grinder's green, medium	1.0	0.40	50	2 to 0.1
25 per cent Grinder's green, deep	1.0	0.40	75	2 to 0.1
C. P. Chromium oxide	2.0	0.40	50	2 to 0.1
C. P. Primrose chrome yellow	1.0	0.20	50	2 to 0.1
C. P. Light chrome yellow	1.0	0.50	50	2 to 0.1
C. P. Medium chrome yellow	1.0	0.30	50	2 to 0.1
C. P. Dark chrome yellow	2.0	0.40	50	2 to 0.1
C. P. Zinc yellow	1.0	0.40	50	2 to 0.1
English vermillion	2.0	0.50	100	2 to 0.1
Ultramarine blue	1.0	0.50	150	2 to 0.1
Cobalt blue	1.0	0.50	150	2 to 0.1
High strength carbon black	0.3	2.80	150	2 to 0.1
Bone black	1.0	0.80	100	2 to 0.1
Lampblack	0.3	1.00	100	2 to 0.1
Carbon black	0.3	1.30	150	2 to 0.1
Ferrite yellow	0.5	0.30	100	2 to 0.1
French yellow ochre	1.0	0.55	100	2 to 0.1
Light red oxide	1.0	0.70	100	2 to 0.1
Indian, Spanish, Venetian, Persian Gulf oxides and metallic brown	1.0	0.40	100	2 to 0.1
Raw and burnt sienna	1.0	0.60	100	2 to 0.1
Raw and burnt umber	1.0	0.80	100	2 to 0.1

NOTE 2.—In many cases, the paint manufacturer producing industrial, freight car, marine, barn or anti-corrosive paints is interested in wetting the pigment with the vehicle. Such methods of grinding in oil do not reduce the particle size or develop additional tinctorial value of the pigment. The covering power of such paints is therefore dependent upon the degree to which the color manufacturer develops the pigment used in such products. The muller tests do not determine the true value of colors for this purpose. The grinding action of the muller develops the tinctorial value and hiding power of the pigment to a much greater extent than when the pigment is ground in oil on a loosely set stone mill. Comparative muller and stone grinding tests show that fifty mulls with no weight on the muller are equivalent to a loose grind on a paint mill in which the pigment is thoroughly wetted. It is recommended that this test be used in determining the true value of these pigments for paints wherein the pigment receives little or no grinding in the paint mill.

NOTE 3.—For the most exact determination of mass color and ultimate tinting strength, it is recommended that the following procedure be employed: The comparison of all samples shall be made at the same or equal consistency and this consistency shall be such that the paste can just be thrown from the spatula by a gentle whipping motion of the hand or by the tapping of the spatula blade with the index finger.

NOTE 4.—To determine the percentage strength of the unknown color in terms of the standard, varying amounts of the mulled paste of the standard color are mixed with the same amount of reduction paste to give a series of standards. The unknown is compared to determine the standard it matches. The tinting strength of the unknown sample is calculated as follows: The ratio of the amount of standard color used to give equality of tint, to the amount of unknown color used multiplied by 100 is the tinting strength of the unknown sample.

Tinting Strength, Pastes

6. When the sample is in the paste form as a color in oil or color in Japan, the tinting strength shall be determined in accordance with the procedure described in Section 4 (*b*) and continuing in Section 5 (*a*) and (*b*).

TENTATIVE SPECIFICATIONS

FOR

PETROLEUM SPIRITS (MINERAL SPIRITS)[1]

A.S.T.M. Designation: D 235 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1926; REVISED, 1934.

Scope

1. These specifications apply only to petroleum distillates.

Properties

2. The material shall conform to the following requirements:

(*a*) *Appearance.*—It shall be clear and free from suspended matter and water.

(*b*) *Color.*—The color shall be "water white," that is, not darker than No. 21 Saybolt Chromometer.

(*c*) *Flash Point.*—The flash point shall not be lower than 100 F. (38 C.) when tested in the Tag closed tester.

(*d*) *Blackening.*—It shall not blacken or corrode clean metallic copper in 30 min. at the boiling point of the spirits.

(*e*) *Distillation Range.*—Not less than 50 per cent shall be recovered in the receiver when the thermometer reads 350 F. (177 C.). The dry or end point shall not be higher than 410 F. (210 C.).

(*f*) *Acidity.*—The residue after distillation shall be neutral.

Methods of Testing

3. The properties enumerated in these specifications shall be determined in accordance with the following methods of test:

(*a*) *Color.*—The test for color shall be in accordance with the Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (A.S.T.M. Designation: D 156 – 34 T) of the American Society for Testing Materials.[2]

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-1 on Preservative Coatings for Structural Materials.

[2] See p. 895.

A fresh aqueous solution of potassium dichromate in distilled water, containing 0.0048 g. $K_2Cr_2O_7$ per liter, is approximately equivalent to No. 21 Saybolt Chromometer.

(*b*) *Flash Point.*—The test shall be made in accordance with the Standard Method of Test for Flash Point of Volatile Flammable Liquids (A.S.T.M. Designation: D 56) of the American Society for Testing Materials.[1]

(*c*) *Blackening.*—A clean strip of mechanically polished pure sheet copper, about ½ in. (1.3 cm.) in width and 3 in. (7.5 cm.) in length, shall be placed in a glass test tube about ¾ in. (1.9 cm.) in width and 18 in. (46 cm.) in length. Sufficient of the sample to be tested shall be added to completely cover the strip and heated rapidly to boiling. It is most convenient to heat the tube by immersion in an oil bath maintained at a temperature slightly higher than the initial boiling point of the mineral spirits. The sample shall be kept boiling for 30 minutes without any actual distillation taking place and the copper strip then examined for blackening. A slight tarnish shall be disregarded, but any marked blackening shall be cause for rejection.

(*d*) *Distillation.*—The test shall be made in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials.[2]

(*e*) *Acidity.*—The cooled residue from the distillation flask shall be collected in a test tube, three volumes of distilled water added, and the tube thoroughly shaken. The mixture shall be allowed to separate and the aqueous layer removed to a clean test tube by means of a pipette. One drop of a 1 per cent solution of methyl orange shall be added. No pink or red color should be formed.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 663.

[2] *Ibid.*, p. 778.

TENTATIVE SPECIFICATIONS

FOR

AMYL ACETATE (FROM FUSEL OIL) (85 TO 88 PER CENT GRADE)[1]

A.S.T.M. Designation: D 318 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Properties

1. Amyl acetate made from fusel oil shall conform to the following requirements:

Specific gravity, 20/20 C	0.860 to 0.865
Color	water white
Distillation range:[a]	
Below 110 C	none
Below 120 C	not more than 15 per cent
Below 130 C	not more than 50 per cent
Below 140 C	not less than 60 per cent
Below 150 C	none
Non-volatile matter	not more than 0.005 g. per 100 ml.
Odor	mild, non-residual
Water	miscible without turbidity with 19 volumes of 60° Baumé gasoline at 20 C.
Acidity (free acid as acetic acid)	not more than 0.03 per cent by weight, equivalent to 0.3 mg. of KOH per gram of sample
Ester value	85 to 88 per cent by weight

[a] The thermometer used for the distillation test shall conform to the requirements of the Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, −20 to +150 C., 0 to +300 F. (A.S.T.M. Designation: D 182) of the American Society for Testing Materials.[2]

Methods of Testing

2. The sampling and methods of testing shall be conducted in accordance with the Standard Methods of Sampling and Testing Lacquer Solvents and Diluents (A.S.T.M. Designation: D 268) of the American Society for Testing Materials.[3]

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-1 on Preservative Coatings for Structural Materials.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

These specifications, when adopted as standard, will be incorporated in the Standard Specifications for Amyl Acetate (Synthetic) (A.S.T.M. Designation: D 318 - 33), 1933 Book of A.S.T.M. Standards, Part II, p. 704.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 1236.

[3] *Ibid.*, p. 722.

TENTATIVE METHODS OF TESTING NITROCELLULOSE CLEAR LACQUERS AND LACQUER ENAMELS[1]

A.S.T.M. Designation: D 333 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1931; REVISED, 1932, 1933, 1934.

Weight per Gallon.

1. (*a*) The weight in pounds per U. S. gallon shall be obtained by multiplying the specific gravity by 8.32. The specific gravity shall be determined by any convenient method that is accurate to three significant figures, the temperature of both sample and water being 20 C.

(*b*) *Mobile Liquids.*—For sufficiently mobile liquids a convenient apparatus is an accurately calibrated volumetric flask.

(*c*) *Viscous Materials.*—For very viscous materials which cannot be conveniently introduced into a volumetric flask, any convenient vessel of known capacity may be used. A suitable apparatus is described in the Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70) of the American Society for Testing Materials.[2]

Drying Time.

2. The sample and a mutually agreed upon standard shall be flowed without thinning, crosswise on a clean 4 by 8-in. glass plate, in a location free from draft, and examined for drying at specified periods such as 3 minutes, 15 minutes, 1 hour, and 24 hours. The drying shall be judged by touching or pressing the films with the finger at approximately the same points.

Gloss.

3. A panel for the gloss test shall be prepared by pouring the sample and a mutually agreed upon standard on an opaque mutually agreed upon surface in such a manner that the two materials flow together along an adjacent edge. The panel shall be examined for gloss after 24 hours. A convenient method of determining apparent gloss is to hold the test panel at an angle of incidence approaching 180 deg. to a source of artificial light and to note the comparative sharpness of the definition of the image (for example, the lamp filament).

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-1 on Preservative Coatings for Structural Materials.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 1002.

Homogeneity.

4. The sample shall be thinned with the thinner recommended, in the proportions recommended. The thinned sample shall be flowed on a glass panel and dried in a dust-free atmosphere. The panel shall be examined by reflected and transmitted light for pigment dispersion and freedom from particles of foreign matter.

Print Test.

5. The test panel for the print test shall be prepared in a manner mutually agreed upon by the buyer and seller. The test panel shall be covered with two pieces of ordinary cheesecloth over which shall be placed a piece of felt about $\frac{3}{32}$ in. in thickness. A known uniform pressure shall then be applied to the felt, over a circular area of at least 1 in. in diameter for a given length of time. The time allowed for the lacquer to dry before applying the pressure shall be also predetermined.

Tests shall be made under definite, predetermined conditions of temperature and humidity, or, if this is not possible, a standard shall be run at the same time.

Bending Test.

6. The composition of the metal test panel for the bending test, the gage thereof and the manner of application of lacquer coating applied thereto, shall be mutually agreed upon by the buyer and seller.

The test shall be made by bending the panel at a uniform rate through an angle of more than 140 deg. over a mandrel of mutually agreed upon radius.

Outdoor Exposure.

7. At least two test panels shall be exposed outdoors on an exposure rack, in full sunlight, at an angle of 45 deg. from the vertical facing south, and examined at regular intervals for color, gloss, etc., and compared with a standard panel prepared and exposed in a manner mutually agreed upon by the buyer and seller.

Non-Volatile Matter.

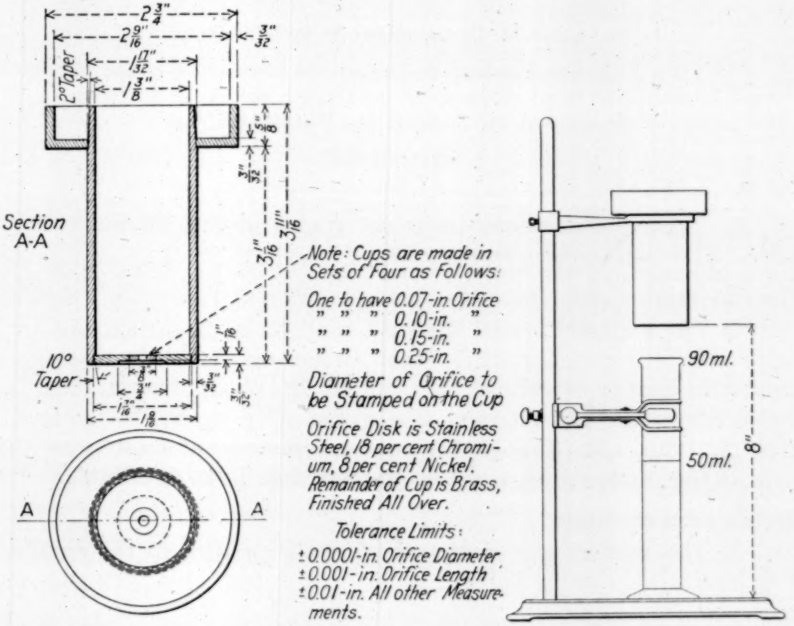
8. (*a*) Weigh into a flat-bottom metal or glass dish containing a stirring rod, from 4 to 6 g. of the sample to be tested, weighing in such a manner as to minimize the loss of volatile solvents. Pour in 100 ml. of acetone and stir until solution of material is complete. Add slowly 10 ml. of water, stirring vigorously. Place the dish on a hot-water bath and allow the solution to evaporate to dryness. Heat for 1 hour in an oven at 100 to 105 C. Allow to cool 20 minutes in a desiccator and weigh. (The dish should be covered in such a manner as to allow solvents to escape and exclude contamination by dirt in the atmosphere.) If the precipitate or residue is lumpy, redissolve in the solvent combination and precipitate again with water.

(*b*) The method of determining non-volatile matter in varnishes, as described in Sections 6 and 7 of the Standard Methods of Testing Oleo-Resinous Varnishes (A.S.T.M. Designation: D 154) of the

American Society for Testing Materials,[1] may be used if mutually agreed upon by the buyer and seller, with the additional requirement that the sample shall be reheated and reweighed until the weight is constant to within 0.001 g.

Consistency Test Apparatus. 9. The consistency cup shall be so designed as to deliver 50 ml. of the sample in from 30 to 100 seconds. A suitable design is shown in Fig. 1.

Consistency Test Procedure. 10. The sample to be tested and the consistency cup shall be brought to a temperature of 25 C. (preferably by means of a thermostat). The consistency cup shall then be mounted in the clamp provided for the purpose and the receiving cylinder placed in position. With the outlet of the cup closed by means of the finger, the sample shall be poured into the cup until it is filled to overflowing. The excess shall then be struck off with a straight edge, the finger over the outlet removed and the sample allowed to flow into the receiving cylinder. The number of seconds from the time the finger is removed from the orifice until the top of the meniscus reaches the 50-ml. mark on the cylinder shall be determined by a stop watch and shall be recorded as the consistency of the material.



Note: Cups are made in Sets of Four as Follows:

One to have 0.07-in. Orifice
" " " 0.10-in. "
" " " 0.15-in. "
" " " 0.25-in. "

Diameter of Orifice to be Stamped on the Cup

Orifice Disk is Stainless Steel, 18 per cent Chromium, 8 per cent Nickel. Remainder of Cup is Brass, Finished All Over.

Tolerance Limits:

±0.0001-in. Orifice Diameter
±0.001-in. Orifice Length
±0.01-in. All other Measurements.

FIG. 1.—Consistency Cups and Test Assembly.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 698.

TENTATIVE SPECIFICATIONS
FOR
FUEL OILS[1]

A.S.T.M. Designation: D 396 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Scope

1. These specifications cover six grades of fuel oil for various types of fuel-oil-burning equipment.

General Requirements

2. The fuel oils herein specified shall be hydrocarbon oils free from acid, grit and fibrous or other foreign matter likely to clog or injure the burner or valves. If required, the oil shall be strained by being drawn through filters or wire gauze of 16 meshes to the inch.[3] The clearance area through the strainers shall be at least twice the area of the suction pipe, and the strainers shall be in duplicate.

Detailed Requirements

3. The various grades of fuel oil shall conform to the detailed requirements shown in Table I.

Methods of Testing

4. The requirements enumerated in these specifications shall be determined in accordance with the following methods of testing of the American Society for Testing Materials, except as may be required under Paragraph (*a*):

(*a*) *Flash Point.*—Standard Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (A.S.T.M. Designation:

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

[3] For detailed requirements for the wire gauze see those prescribed for the U. S. Standard No. 16 (1190-micron) sieve in the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

TABLE I.—DETAILED REQUIREMENTS FOR FUEL OILS.[a]

Grade	Flash Point, deg. Fahr.		Pour Point, deg. Fahr.	Water and Sediment, per cent	Carbon Residue, per cent	Ash, per cent	Distillation Temperatures, deg. Fahr.					Viscosity, seconds			
							10 per cent Point	90 per cent Point		End Point		Saybolt Universal (at 100 F.)		Saybolt Furol (at 122 F.	
	Min.	Max.	Max.	Max.	Max.	Max.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
No. 1 { A distillate oil for use in burners requiring a volatile fuel......... }	100 or legal	150	15[b]	0.05	0.02	....	420	....	....	600	....	....	....	....	....
No. 2 { A distillate oil for use in burners requiring a moderately volatile fuel......................... }	110 or legal	190	15[b]	0.05	0.05	....	440	620	....	....	600	....	....	....	....
No. 3 { A distillate oil for use in burners requiring a low-viscosity fuel.... }	110 or legal	200	15[b]	0.1	0.15	....	....	....	620[d]	....	....	70	....	....	....
No. 4 { An oil for use in burners requiring low-viscosity fuel.............. }	150	....	[c]	1.0	....	0.1	....	....	....	....	....	500	70[e]	....	....
No. 5 { An oil for use in burners equipped with preheaters permitting a medium-viscosity fuel............ }	150	....	....	1.0	....	0.15	....	....	....	....	....	....	....	100	25
No. 6 { An oil for use in burners equipped with preheaters permitting a high-viscosity fuel.............. }	150	....	....	2.0[f]	....	....	....	....	....	....	....	....	....	300	100[g]

---

[a] Recognizing the necessity for low sulfur fuel oils used in connection with heat-treatment, non-ferrous-metal, glass and ceramic furnaces and other special uses, a sulfur requirement may be specified in accordance with the following table:

GRADE OF FUEL OIL	SULFUR, MAX., PER CENT
No. 1	0.5
No. 2	0.5
No. 3	0.75
No. 4	1.25
No. 5	no limit
No. 6	no limit

Other sulfur limits may be specified only by mutual agreement between the buyer and seller.

[b] Lower or higher pour points may be specified whenever required by conditions of storage or use. However, these specifications shall not require a pour point lower than 0 F. under any conditions.

[c] Pour point may be specified whenever required by conditions of storage or use. However, these specifications shall not require a pour point lower than 15 F. under any conditions.

[d] This requirement shall be waived when the carbon residue is more than 0.07 per cent and less than 0.15 per cent.

[e] This requirement shall be waived when the carbon residue is more than 1.0 per cent.

[f] A deduction in quantity shall be made for all water and sediment in excess of 1.0 per cent.

[g] This requirement shall be waived when the carbon residue is 4 per cent or more.

D 93),[1] except where other methods are prescribed by law for the determination of minimum flash point.

(*b*) *Pour Point.*—Standard Method of Test for Cloud and Pour Points (A.S.T.M. Designation: D 97).[2]

(*c*) *Water and Sediment.*—Standard Method of Test for Water and Sediment in Petroleum Products by Means of Centrifuge (A.S.T.M. Designation: D 96).[3]

(*d*) *Carbon Residue.*—Standard Method of Test for Carbon Residue of Petroleum Products (Conradson Carbon Residue) (A.S.T.M. Designation: D 189).[4]

(*e*) *Ash.*—Procedure for determination of ash as described in the Standard Methods of Analysis of Grease (A.S.T.M. Designation: D 128).[5]

(*f*) *Distillation.*—Distillation of Grade No. 1 oil shall be determined in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86),[6] and of Grades Nos. 2 and 3 in accordance with the Standard Methods of Testing Gas Oils (Gravity, Distillation, Sulfur, Carbon Residue, Pour Point, Viscosity, Water) (A.S.T.M. Designation: D 158).[7]

(*g*) *Viscosity.*—Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (A.S.T.M. Designation: D 88).[8]

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 805.

[2] 1934 Supplement to Book of A.S.T.M. Standards, p. 117.

[3] 1933 Book of A.S.T.M. Standards, Part II, p. 895.

[4] *Ibid.*, p. 757.

[5] *Ibid.*, p. 827.

[6] *Ibid.*, p. 778.

[7] *Ibid.*, p. 814.

[8] *Ibid.*, p. 880.

TENTATIVE METHOD OF TEST

FOR

COLOR OF LUBRICATING OILS BY MEANS OF A.S.T.M. UNION COLORIMETER[1]

A.S.T.M. Designation: D 155 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1923; REVISED, 1932, 1934.

Scope

1. The color of lubricating oil shall be determined by means of the A.S.T.M. Union Colorimeter.

Apparatus

2. (*a*) The A.S.T.M. Union Colorimeter shall bear a metal name plate marked with the following description and a serial number:

A.S.T.M. UNION COLORIMETER
Licensed under U. S. Patent No. 1,495,763.

(*b*) The A.S.T.M. Union Colorimeter, Fig. 1, shall consist of a box, *a*, a glass jar, a light shield, *b*, and a daylight lamp, *c*. A magazine containing the glass color standards shall be an integral part of the box.

Box

(*c*) The box, *a*, Fig. 1, shall be constructed of metal or wood and shall be approximately 18 in. (457 mm.) in length. The approximate inside dimensions shall be 1½ in. (38 mm.) in depth, 2⅛ in. (54 mm.) in width at the observation end and 3 in. (76 mm.) in width at the illumination end. The box shall have an interior finish of dull black and shall be so constructed as to preclude the entrance of any extraneous light.

A transverse vertical partition with a centrally-located opening ½ in. (13 mm.) in diameter shall be placed 1⅛ in. (28 mm.) from the observation end of the box. A second transverse vertical partition shall be placed so that the side nearer the illumination end shall be approximately 2⅛ in. (54 mm.) from that end. This partition shall be approximately 1 in. (25 mm.) thick and shall have in the left half a vertical aperture in which the magazine, containing the glass color standards, is mounted. This partition shall have two horizontal openings approximately $\frac{9}{16}$ in. (14 mm.) in diameter at the observation end and $\frac{3}{4}$ in. (19 mm.) in diameter at the illumination end located midway between the top and the bottom of the partition. The openings shall be spaced $1\frac{1}{2}$ in. (38 mm.) between centers and located symmetrically in regard to the center line. Suitable mechanism shall be provided for raising and lowering the magazine. An opening shall be located in the left side of the box to permit the reading, by means of a mirror, of the color numbers stamped, as mirror images, on the side of the magazine. A flashed opal glass approximately $3\frac{1}{4}$ by $1\frac{3}{4}$ by $\frac{1}{16}$ in. (82 by 44 by 1.5 mm.) shall be mounted across the illumination end of the box. This glass, used as an intercepting light diffuser, shall be especially selected to be free from bubbles and other imperfections, shall be uniform as to density and thickness of the opal flash, and particularly shall be of such integral color as to result in minimum selective absorption. A vertical partition, approximately $\frac{1}{8}$ in. (3 mm.) in thickness, shall extend along the horizontal axis of the box from the opal glass to the transverse partition which contains the magazine. This partition divides the illumination end of the box into two compartments. In the top of the box, centrally located

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

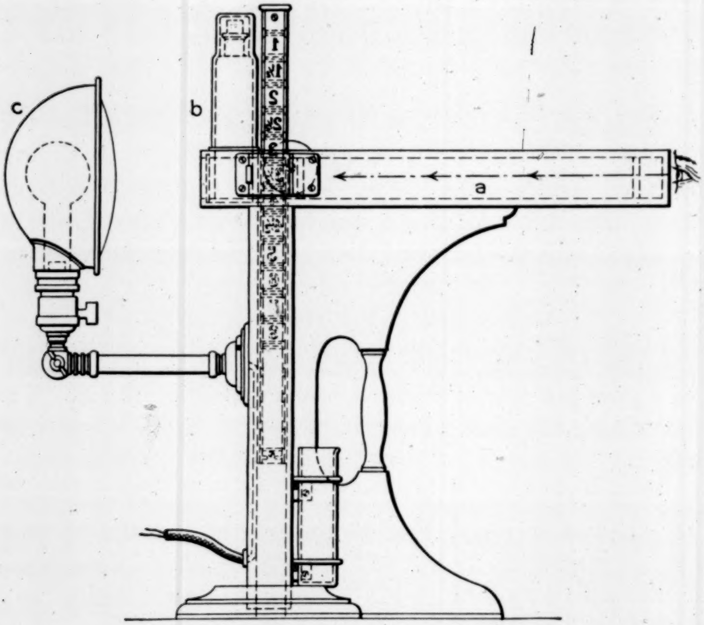


FIG. 1.—A.S.T.M. Union Colorimeter.

over these two compartments, there shall be circular openings of such size as to accommodate the standard jar and 4-oz. sample bottles.

Color Standards

(*d*) The glass color standards shall be 12 in number as specified in Table I. These glasses shall be mounted in a magazine. The magazine shall have an additional opening containing no glass standard so that two bottles of oil may be compared in the colorimeter. The width of the glass color standards shall be not less than $\frac{5}{8}$ in. (16 mm.).

Glass Test Jar

(*e*) The standard glass jar, Fig. 2, shall be a true cylinder of clear colorless glass. The internal diameter shall be not less than $1\frac{9}{32}$ in. (32.5 mm.) nor more than $1\frac{5}{16}$ in. (33.5 mm.). The thickness of the wall shall be $\frac{1}{16}$ in. ± $\frac{1}{64}$ in. (1.5 mm. ± 0.25 mm.). The height of the cylinder shall be 5 in. ± $\frac{1}{4}$ in. (127 mm. ± 6 mm.).

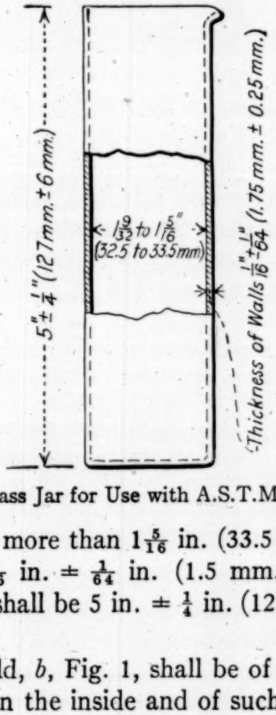

5" ± 1/4" (127 mm. ± 6 mm.)
1 9/32 to 1 5/16"
(32.5 to 33.5 mm)
Thickness of Walls 1/16" ± 1/64" (1.75 mm. ± 0.25 mm.)

FIG. 2.—Standard Glass Jar for Use with A.S.T.M. Union Colorimeter.

Light Shield

(*f*) The light shield, *b*, Fig. 1, shall be of any suitable material. It shall be dull black on the inside and of such size as to shield completely all light from the tops of the cylinders, or oil sample bottles, when they are in place in the colorimeter.

Light Source

(*g*) The light shall be supplied by an artificial daylight lamp so arranged as to project a diffused light with the absence of glare or shadow upon the flashed opal glass. When in normal position the near surface of the daylight filter shall be 4 in. (102 mm.) from the flashed opal glass. The artificial daylight lamp shall be used for referee work. When electric current is not available, the colorimeter may be used by exposing the flashed opal glass to northern daylight provided there are no colored objects in the immediate foreground.

Artificial Daylight Lamp

(*h*) The artificial daylight lamp assembly, *c*, Fig. 1, may for convenience be fastened to the base supporting the box and shall consist of a lamp and socket, a reflector and a daylight filter glass. The lamp shall be a 60-watt Mazda, A21 bulb, clear glass, inside frost finish, maintained at 12.3 lumens per watt, furnishing light at a color temperature of approximately 2750°K. The lamp shall be fitted into a socket equipped with a reflector, hemispherical in form, the interior surface of which shall be finished with a brilliant aluminum-bronze powder, free from mica and other adulterants, applied with a heat-resisting bronzing liquid, sprayed uniformly over the surface. This finish shall be such as to be free from selective absorption and have an initial reflectivity above 65 per cent. A daylight filter glass, concave-convex in form, shall be closely fitted over the opening in the hemispherical reflector and attached in such a manner as to be dust tight. The glass shall be finished on its concave surface by sand-blasting and acid-smoothing or fortifying.

NOTE.—A spectrophotometric test of an acceptable daylight filter glass shall indicate a transmission of radiant energy not less than 60 per cent at 410 mμ. with a smooth curve down to a transmission below 10 per cent at 700 mμ. This curve, furthermore, shall be without the pronounced hump which is characteristic of excess cobalt, the typical cobalt curve having an increased transmission at wave length of 570 mμ. above a straight line drawn between the points 540 mμ. and 590 mμ., and also a transmission band in the red for wave lengths of 660 mμ. and greater. This variation in an acceptable filter may not at 570 mμ. exceed 0.03 above the straight line drawn between 540 mμ. and 590 mμ., nor shall the transmission for wave length 700 mμ. exceed the transmission for any shorter wave length such as 660 mμ. by more than 0.03.

An acceptable daylight filter shall also possess such characteristics that the trilinear coordinates x, y, and z, and the luminous transmission T_w, when calculated from the spectral transmission data using the 1931 I.C.I.[1] Standard Illuminant *A*,[2] shall be as follows:

T_w	0.107 to 0.160
x	0.314 to 0.330
y	0.337 to 0.341
z	0.329 to 0.349

Procedure for Oils not Darker than 8 Color

3. Oil not darker than 8 color, when examined, shall be at room temperature unless its cloud point is above the temperature of the

---

[1] International Commission on Illumination.

[2] Dorothy B. Judd, "The 1931 I.C.I. Standard Observer and Coordinate System for Colorimetry," *Journal*, Optical Soc. America, Vol. 10, p. 365, October, 1933.

room, in which case the oil shall be heated to a temperature of not more than 10 F. (5.6 C.) above its cloud point. The oil to be examined may be observed in the ordinary 4-oz. sample bottle, but in referee work a standard jar shall be used. The jar shall be placed in the right-hand compartment while in the other compartment shall be placed a 4-oz. sample bottle of distilled water. The jar and bottle shall be covered with the shield, and the artificial daylight lamp lighted. The color of the oil is obtained by determining the glass color standard which most nearly matches the color of the oil under examination. The colors of oils which are intermediate to the standard colors may be expressed in terms of the darker standard as "lighter than" or "minus."

NOTE: *Example.*—When an oil has a color between 7 and 8, the color may be expressed as "lighter than 8" or "8 minus."

The daylight lamp may be brought closer to the opal glass in determining the darker colors.

TABLE I.—GLASS COLOR STANDARDS OF A.S.T.M. UNION COLORIMETER.

A.S.T.M. Color Numbers	National Petroleum Association Color Numbers	National Petroleum Association Names	Lovibond Analysis		
			Red 200 Series	Yellow 510 Series	Blue 1180 Series
1	No. 1 N.P.A.	Lily White	0.12	2.4	....
1½	No. 1½ N.P.A	Cream White	0.60	8.0	....
2	No. 2 N.P.A.	Extra Pale	2.5	26.0	....
2½	No. 2½ N.P.A	Extra Lemon Pale	4.6	27.0	....
3	No. 3 N.P.A.	Lemon Pale	6.9	32.0	....
3½	No. 3½ N.P.A	Extra Orange Pale	9.4	45.0	....
4	No. 4 N.P.A.	Orange Pale	14.0	50.0	0.55
4½	No. 4½ N.P.A	Pale	21.0	56.0	0.55
5	No. 5 N.P.A.	Light Red	35.0	93.0	....
6	No. 6 N.P.A.	Dark Red	60.0	60.0	0.55
7	No. 7 N.P.A.	Claret Red	60.0	106.0	1.8
8	No. 8 N.P.A.		166.0	64.0	....

Procedure for Oils Darker than 8 Color

4. Oils darker than 8 color shall be diluted with kerosine. The color of the kerosine shall be not darker than +21 as determined in accordance with the Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (A.S.T.M. Designation: D 156 - 34 T) of the American Society for Testing Materials.[1] A mixture of exactly 15 per cent by volume of oil, and 85 per cent by volume of kerosine shall be used in all cases. The color of the mixture shall be obtained in accordance with the procedure described in Section 3.

The numbers designating the color of all oils which have been diluted to make the determination shall be followed by the designation "Dil."

---

[1] See p. 895.

TENTATIVE METHOD OF TEST

FOR

COLOR OF PETROLATUM BY MEANS OF A.S.T.M. UNION COLORIMETER[1]

A.S.T.M. Designation: D 218 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1925; REVISED, 1932, 1934.

Scope

1. The color of petrolatum shall be determined by means of the A.S.T.M. Union Colorimeter.

Apparatus

2. (*a*) The A.S.T.M. Union Colorimeter shall bear a metal name plate marked with the following description and a serial number:

A.S.T.M. UNION COLORIMETER
Licensed under U. S. Patent No. 1,495,763.

(*b*) The A.S.T.M. Union Colorimeter, Fig. 1, shall consist of a box, *a*, a glass jar, a light shield, *b*, and a daylight lamp, *c*. A magazine containing the glass color standards shall be an integral part of the box.

Box

(*c*) The box, *a*, Fig. 1, shall be constructed of metal or wood and shall be approximately 18 in. (457 mm.) in length. The approximate inside dimensions shall be 1½ in. (38 mm.) in depth, 2⅛ in. (54 mm.) in width at the observation end and 3 in. (76 mm.) in width at the illumination end. The box shall have an interior finish of dull black and shall be so constructed as to preclude the entrance of any extraneous light.

A transverse vertical partition with a centrally-located opening ½ in. (13 mm.) in diameter shall be placed 1⅛ in. (28 mm.) from the observation end of the box. A second transverse vertical partition shall be placed so that the side nearer the illumination end shall be approximately 2⅛ in. (54 mm.) from that end. This partition shall be approximately 1 in. (25 mm.) thick and shall have in the left half a vertical aperture in which the magazine, containing the glass color standards, is mounted. This partition shall have two horizontal openings approximately $\frac{9}{16}$ in. (14 mm.) in diameter at the observation end and $\frac{3}{4}$ in. (19 mm.) in diameter at the illumination end located midway between the top and the bottom of the partition. The openings shall be spaced $1\frac{1}{2}$ in. (38 mm.) between centers and located symmetrically in regard to the center line. Suitable mechanism shall be provided for raising and lowering the magazine. An opening shall be located in the left side of the box to permit the reading, by means of a mirror, of the color numbers stamped, as mirror images, on the side of the magazine. A flashed opal glass approximately $3\frac{1}{4}$ by $1\frac{3}{4}$ by $\frac{1}{16}$ in. (82 by 44 by 1.5 mm.) shall be mounted across the illumination end of the box. This glass, used as an intercepting light diffuser, shall be especially selected to be free from bubbles and other imperfections, shall be uniform as to density and thickness of the opal flash, and particularly shall be of such integral color as to result in minimum selective absorption. A vertical partition, approximately $\frac{1}{8}$ in. (3 mm.) in thickness, shall extend along the horizontal axis of the box from the opal glass to the transverse partition which contains the magazine. This partition divides the illumination end of the box into two compartments. In the top of the box, centrally located over these two compartments, there shall be circular openings of such size as to accommodate the standard jar and 4-oz. sample bottles.

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

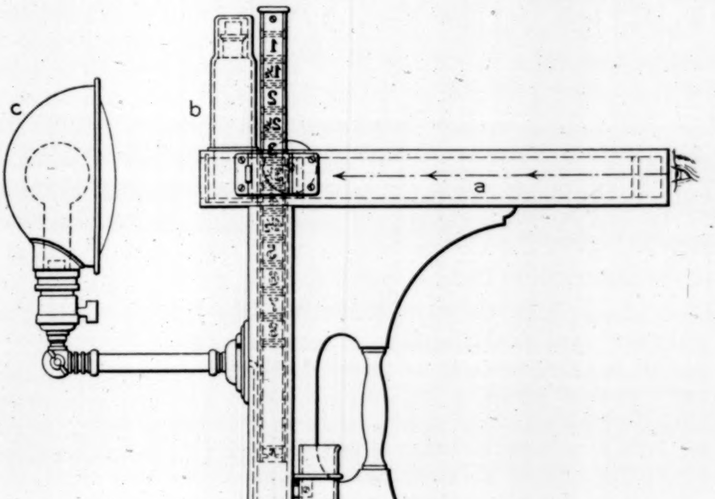


FIG. 1.—A.S.T.M. Union Colorimeter.

Color Standards

(*d*) The glass color standards shall be 12 in number as specified in Table I. These glasses shall be mounted in a magazine. The magazine shall have an additional opening containing no glass standard so that two bottles of petrolatum may be compared in the colorimeter. The width of the glass color standards shall be not less than $\frac{5}{8}$ in. (16 mm.).

Glass Test Jar

(*e*) The standard glass jar, Fig. 2, shall be a true cylinder of clear colorless glass. The internal diameter shall be not less than $1\frac{9}{32}$ in. (32.5 mm.) nor more than $1\frac{5}{16}$ in. (33.5 mm.). The thickness of the wall shall be $\frac{1}{16}$ in. ± $\frac{1}{64}$ in. (1.5 mm. ± 0.25 mm.). The height of the cylinder shall be 5 in. ± $\frac{1}{4}$ in. (127 mm. ± 6 mm.).

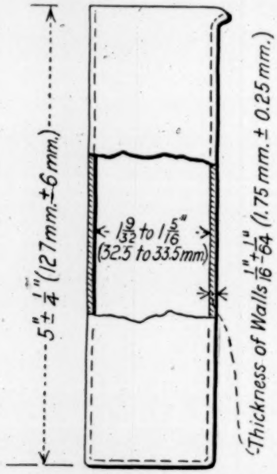

5" ± 1/4" (127 mm. ± 6 mm.)
1 9/32 to 1 5/16" (32.5 to 33.5 mm)
Thickness of Walls 1/16" ± 1/64" (1.75 mm. ± 0.25 mm.)

FIG. 2.—Standard Glass Jar for Use with A.S.T.M. Union Colorimeter.

Light Shield

(*f*) The light shield, *b*, Fig. 1, shall be of any suitable material. It shall be dull black on the inside and of such size as to shield completely all light from the tops of the cylinders, or oil sample bottles, when they are in place in the colorimeter.

Light Source

(*g*) The light shall be supplied by an artificial daylight lamp so arranged as to project a diffused light with the absence of glare or shadow upon the flashed opal glass. When in normal position the near surface of the daylight filter shall be 4 in. (102 mm.) from the flashed opal glass. The artificial daylight lamp shall be used for referee work. When electric current is not available, the colorimeter may be used by exposing the flashed opal glass to northern daylight provided there are no colored objects in the immediate foreground.

Artificial Daylight Lamp

(*h*) The artificial daylight lamp assembly, *c*, Fig. 1, may for convenience be fastened to the base supporting the box and shall consist of a lamp and socket, a reflector and a daylight filter glass. The lamp shall be a 60-watt Mazda, A21 bulb, clear glass, inside frost finish, maintained at 12.3 lumens per watt, furnishing light at a color temperature of approximately 2750°K. The lamp shall be fitted into a socket equipped with a reflector, hemispherical in form, the interior surface of which shall be finished with a brilliant aluminum-bronze powder, free from mica and other adulterants, applied with a heat-resisting bronzing liquid, sprayed uniformly over the surface. This finish shall be such as to be free from selective absorption and have an initial reflectivity above 65 per cent. A daylight filter glass, concave-convex in form, shall be closely fitted over the opening in the hemispherical reflector and attached in such a manner as to be dust tight. The glass shall be finished on its concave surface by sand-blasting and acid-smoothing or fortifying.

NOTE.—A spectrophotometric test of an acceptable daylight filter glass shall indicate a transmission of radiant energy not less than 60 per cent at 410 mμ. with a smooth curve down to a transmission below 10 per cent at 700 mμ. This curve, furthermore, shall be without the pronounced hump which is characteristic of excess cobalt, the typical cobalt curve having an increased transmission at wave length of 570 mμ. above a straight line drawn between the points 540 mμ. and 590 mμ., and also a transmission band in the red for wave lengths of 660 mμ. and greater. This variation in an acceptable filter may not at 570 mμ. exceed 0.03 above the straight line drawn between 540 mμ. and 590 mμ., nor shall the transmission for wave length 700 mμ. exceed the transmission for any shorter wave length such as 660 mμ. by more than 0.03.

An acceptable daylight filter shall also possess such characteristics that the trilinear coordinates x, y, and z, and the luminous transmission T_w, when calculated from the spectral transmission data using the 1931 I.C.I.[1] Standard Illuminant *A*,[2] shall be as follows:

T_w	0.107 to 0.160
x	0.314 to 0.330
y	0.337 to 0.341
z	0.329 to 0.349

Procedure for Petrolatums not Darker than 8 Color

3. Petrolatums not darker than 8 color, when examined, shall be heated to from 20 to 30 F. (11 to 17 C.) above the melting point.

---

[1] International Commission on Illumination.

[2] Dorothy B. Judd, "The 1931 I.C.I. Standard Observer and Coordinate System for Colorimetry," *Journal*, Optical Soc. America, Vol. 10, p. 365, October, 1933.

The petrolatum to be examined may be observed in the ordinary 4-oz. sample bottle, but in referee work a standard jar shall be used. The jar shall be placed in the right-hand compartment while in the other compartment shall be placed a 4-oz. sample bottle of distilled water. The jar and bottle shall be covered with the shield, and the artificial daylight lamp lighted. The color of the petrolatum is obtained by determining the glass color standard which most nearly matches the color of the petrolatum under examination. The colors of petrolatums which are intermediate to the standard colors may be expressed in terms of the darker standard as "lighter than" or "minus."

NOTE: *Example.*—When a petrolatum has a color between 7 and 8, the color may be expressed as "lighter than 8" or "8 minus."

The daylight lamp may be brought closer to the opal glass in determining the darker colors.

TABLE I.—GLASS COLOR STANDARDS OF A.S.T.M. UNION COLORIMETER.

A.S.T.M. Color Numbers	National Petroleum Association Color Numbers	National Petroleum Association Names	Lovibond Analysis		
			Red 200 Series	Yellow 510 Series	Blue 1180 Series
1	No. 1 N.P.A	Lily White	0.12	2.4	....
1½	No. 1½ N.P.A	Cream White	0.60	8.0	....
2	No. 2 N.P.A	Extra Pale	2.5	26.0	....
2½	No. 2½ N.P.A	Extra Lemon Pale	4.6	27.0	....
3	No. 3 N.P.A	Lemon Pale	6.9	32.0	....
3½	No. 3½ N.P.A	Extra Orange Pale	9.4	45.0	....
4	No. 4 N.P.A	Orange Pale	14.0	50.0	0.55
4½	No. 4½ N.P.A	Pale	21.0	56.0	0.55
5	No. 5 N.P.A	Light Red	35.0	93.0	....
6	No. 6 N.P.A	Dark Red	60.0	60.0	0.55
7	No. 7 N.P.A	Claret Red	60.0	106.0	1.8
8	No. 8 N.P.A	....	166.0	64.0	....

Procedure for Petrolatums Darker than 8 Color

4. Petrolatums darker than 8 color shall be diluted with kerosine. The color of the kerosine shall be not darker than +21 as determined in accordance with the Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (A.S.T.M. Designation: D 156 – 34 T) of the American Society for Testing Materials.[1] A mixture of exactly 15 per cent by volume of petrolatum, and 85 per cent by volume of kerosine shall be used in all cases. The kerosine shall be heated to a temperature 20 to 30 F. (11 to 17 C.) above the melting point of the petrolatum under examination before the mixture is made. The color of the mixture shall be obtained in accordance with the procedure described in Section 3.

The numbers designating the color of all petrolatums which have been diluted to make the determination, shall be followed by the designation "Dil."

---

[1] See p. 895.

TENTATIVE METHOD OF TEST

FOR

COLOR OF REFINED PETROLEUM OIL BY MEANS OF SAYBOLT CHROMOMETER[1]

A.S.T.M. Designation: D 156 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1923; REVISED, 1934.

Scope

1. The color of all refined oils (naphthas, kerosines, etc.) shall be determined by means of the Saybolt Chromometer.

Saybolt Chromometer

2. (*a*) *Glass Tubes.*—The Saybolt Chromometer shall consist of two glass tubes having an internal diameter of not less than 14 mm. nor more than 16 mm. One glass tube, 20 in. in length, shall be permanently closed at one end with a colorless, plano glass disk, and be mounted in a suitable metal collar, provided with a small pet-cock, for the purpose of draining the tube. This glass tube shall be graduated in $\frac{1}{8}$-in. divisions, numbered in inches. The other tube, 19 in. in length, shall be open at both ends, one end being mounted in a suitable metal collar which will hold the color standards and a black metal diaphragm with a circular aperture 12 mm. in diameter. The mounting of this tube shall be such as to give equal length to both tubes. The tubes shall be mounted vertically and shall be covered at their upper end with a removable diaphragmed metal cap about 1 in. in length and of sufficient diameter to easily slip over the end of the tubes. The circular diaphragm aperture shall be 14 mm. in diameter.

(*b*) *Optical System.*—The instrument shall be provided with a suitable optical head consisting of prisms and eyepiece. The prisms shall be of a suitable form, matched in their refracting angles and areas, and so mounted as to avoid possibility of disarrangement. They shall be so arranged that the light rays passing through the tubes shall be deflected to a central aperture which is viewed by the eyepiece. The arrangement shall be such as to provide a circular field of vision free from distortion and parallax, the two halves of which are illuminated by the light transmitted by the sample and the color standard, respectively.

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

Illumination

3. (*a*) Light shall be provided by means of a reflecting mirror with a finely frosted surface set at a suitable angle and so arranged that the reflected light shall pass through suitable openings and through the glass tubes in parallel rays; or it shall be provided by projecting a diffused light directly up through the tubes, from the base of the instrument.

TABLE I.—SAYBOLT CHROMOMETER COLOR CORRESPONDING TO DEPTHS OF OIL.

NUMBER OF DISKS	DEPTH OF OIL, IN.	COLOR	NUMBER OF DISKS	DEPTH OF OIL, IN.	COLOR
One-half.....	20.00	+30	Two........	6.00	+6
One-half.....	18.00	+29	Two........	5.75	+5
One-half.....	16.00	+28	Two........	5.50	+4
One-half.....	14.00	+27	Two........	5.25	+3
One-half.....	12.00	+26	Two........	5.00	+2
One.........	20.00	+25	Two........	4.75	+1
One.........	18.00	+24	Two........	4.50	0
One.........	16.00	+23	Two........	4.25	−1
One.........	14.00	+22	Two........	4.00	−2
One.........	12.00	+21	Two........	3.75	−3
One.........	10.75	+20	Two........	3.625	−4
One.........	9.50	+19	Two........	3.50	−5
One.........	8.25	+18	Two........	3.375	−6
One.........	7.25	+17	Two........	3.25	−7
One.........	6.25	+16	Two........	3.125	−8
Two........	10.50	+15	Two........	3.00	−9
Two........	9.75	+14	Two........	2.875	−10
Two........	9.00	+13	Two........	2.75	−11
Two........	8.25	+12	Two........	2.625	−12
Two........	7.75	+11	Two........	2.50	−13
Two........	7.25	+10	Two........	2.375	−14
Two........	6.75	+9	Two........	2.25	−15
Two........	6.50	+8	Two........	2.125	−16
Two........	6.25	+7			

Light Source

(*b*) The light shall be supplied by an artificial daylight lamp so arranged as to project a diffused light with the absence of glare or shadow on the reflecting mirror or directly up through the tubes. Light from all other sources shall be excluded. The artificial daylight lamp shall be used for referee work. When electric current is not available, the chromometer may be used by exposing the mirror to northern daylight provided there are no colored objects in the immediate foreground.

Daylight Lamp

(*c*) The artificial daylight lamp assembly shall consist of a lamp and socket, a reflector and a daylight filter glass. The lamp shall be a 60-watt Mazda, A21 bulb, clear glass, inside frost finish, maintained at 12.3 lumens per watt, furnishing light at a color temperature of approximately 2750° K. The lamp shall be fitted into a socket equipped with a reflector, hemispherical in form, the interior surface of which shall be finished with a brilliant aluminum bronze powder, free from mica and other adulterants, applied with a heat-resisting bronzing liquid, sprayed uniformly over the surface. This finish shall be such as to be free from selective absorption and have an initial reflectivity above 65 per cent. A daylight filter glass, concave-convex in form, shall be closely fitted over the opening in the hemispherical reflector and attached in such a manner as to be dust tight. The glass shall be finished on its concave surface, by sandblasting and acid-smoothing or fortifying.

NOTE.—A spectrophotometric test of an acceptable filter shall indicate a transmission of radiant energy not less than 60 per cent at 410 mμ. with a smooth curve down to a transmission below 10 per cent at 700 mμ. This curve, furthermore, shall be without the pronounced hump which is characteristic of excess cobalt, the typical cobalt curve having an increased transmission at wave length of 570 mμ. above a straight line drawn between the points 540 mμ. and 590 mμ., and also a transmission band in the red for wave lengths of 660 mμ. and greater. This variation in an acceptable filter may not at 570 mμ. exceed 0.03 above the straight line drawn between 540 mμ. and 590 mμ., nor shall the transmission for wave length 700 mμ. exceed the transmission for any shorter wavelength such as 660 mμ. by more than 0.03.

An acceptable daylight filter shall also possess such characteristics that the trilinear coordinates x, y, and z, and the luminous transmission T_w, when calculated from the spectral transmission data using the 1931 I.C.I.[1] Standard Illuminant *A*,[2] shall be as follows:

T_w	0.107 to 0.160
x	0.314 to 0.330
y	0.337 to 0.341
z	0.329 to 0.349

Color Standards

4. The color standards shall consist of glass disks and one-half disks of such colorimetric characteristics that the trilinear coordinates x, y and z, and the luminous transmission T_w, when calculated from the spectral transmission data using the 1931 I.C.I.[1] Standard Illuminant *C*,[2] shall be as follows:

	WHOLE DISKS	ONE-HALF DISKS
T_w	0.860 to 0.865	0.888 to 0.891
x	0.342 to 0.350	0.327 to 0.331
y	0.367 to 0.378	0.344 to 0.350
z	0.272 to 0.291	0.319 to 0.330

---

[1] International Commission on Illumination.

[2] Dorothy B. Judd, "The 1931 I.C.I. Standard Observer and Coordinate System for Colorimetry," *Journal*, Optical Soc. America, Vol. 10, p. 365, October, 1933.

Procedure

5. The oil tube shall be cleansed by rinsing with some of the oil to be tested, care being taken to allow the tube to drain thoroughly. The pet-cock on the oil tube shall then be closed and the tube shall be filled with the oil to be tested to a depth of 12 in. If at this depth the color of the oil is lighter than one-half disk, the one-half disk shall be used for the test. If it is darker, the oil level shall be lowered to 10.5 in. and the color compared to two disks. If the color of the oil is lighter than two disks, one disk shall be used and if darker, two disks shall be used. After determining the number of disks to be used and with the proper number in place, the level in the oil tube shall be raised if necessary until the color of the oil is decidedly darker than the color standard. The oil shall then be drawn off slowly by means of the pet-cock until the oil appears slightly darker than the color standard. The oil shall then be drawn down to the nearest depth corresponding to a standard color as shown in Table I. If the color of the oil observed through the eyepiece is still darker than the color standard, the oil shall be drawn down to the next depth given in Table I and examined again. This operation shall be continued until the oil and color standard match or show questionable differences. The column of oil shall be lowered one color more and if the oil is unmistakably lighter than the color standard, the previous color shall be recorded as the Saybolt Chromometer Color.

APPENDIX

The following examples of the procedure are given:

Using One Disk

Oil darker at depth of	16 in.
Oil darker at depth of	14 in.
Oil questionable at depth of	12 in.
Oil lighter at depth of	10.75 in.
Color is	+21

Using Two Disks

Oil darker at depth of	4.5 in.
Oil darker at depth of	4.25 in.
Oil questionable at depth of	4.0 in.
Oil lighter at depth of	3.75 in.
Color is	−2

TENTATIVE METHOD OF TEST
FOR
GUM CONTENT OF GASOLINE[1]

A.S.T.M. Designation: D 381 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Scope

1. This test is a means of determining the amount of gum existent at the time of test in gasoline and other motor fuels boiling within the gasoline range. The results are indicative of the amount of gum deposition which may take place in service if the gasoline is used immediately but give no indication of the gum stability of the gasoline upon storage. Results obtained by this test are comparative only, inasmuch as the amount of gum residue obtainable from a given sample varies with the conditions of evaporation. In cases where the sample contains other dissolved non-volatile material, such as lubricating oil, such material may be obtained as residue along with possible gum; such samples obviously require special treatment, depending on the nature of the non-volatile material.

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Beakers.*—Berzelius-type beakers of heat-resistant glass, without lip, of 100-ml. nominal capacity.

(*b*) *Bath.*—The bath shall consist of a closed vessel provided with a reflux condenser, a well into which the beaker fits, a coil for preheating the air as prescribed in Section 3, and a conical adapter to deliver the air into the center of the beaker. A suitable form of apparatus is shown in Fig. 1. A multiple bath having similar provisions is also satisfactory. The bath shall be filled to within 1 in. of the top with a stable liquid having a boiling point within a temperature range from 320 to 330 F. (160 to 165.8 C.), ethylene glycol containing approximately 3 per cent water being suitable for the purpose. The bath shall be insulated with asbestos. An electric hot plate capable of keeping the liquid boiling actively is the preferred heating means. In the absence of a satisfactory hot plate the bath may be heated by a gas burner, in which case the apparatus shall be placed in a hood with a good draft.

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

[2] Accepted for publication as tentative by Committee E-10 on Standards, January 30, 1934.

(*c*) *Air Supply.*—Low-pressure air, passing through a cotton or glass-wool filter and delivered to the preheater inlet of the bath. A flow meter or other air-measuring device shall be provided as shown in Fig. 1.

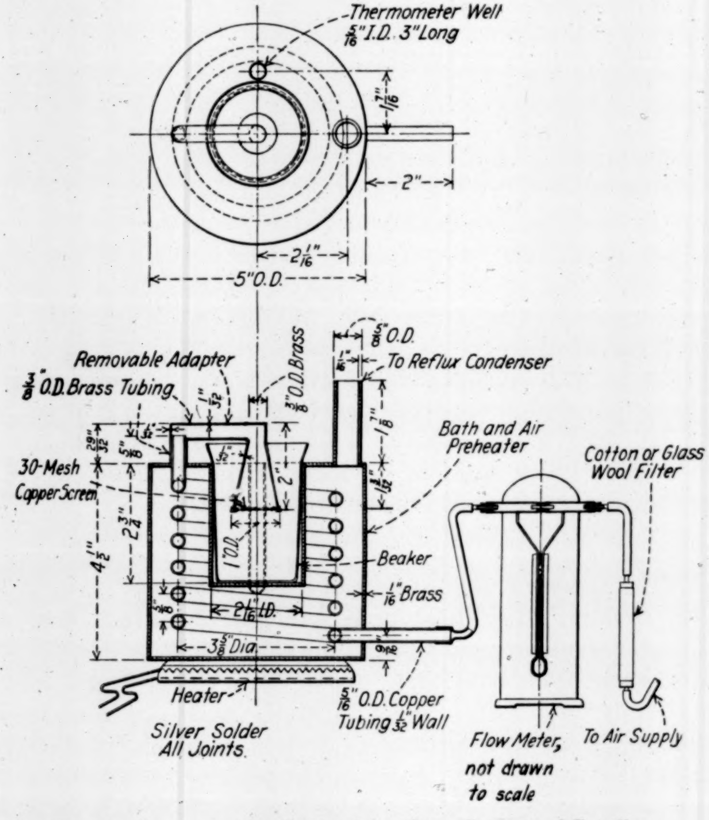

Thermometer Well
$\frac{5}{16}$" I.D. 3" Long
$1\frac{7}{16}$"
2"
$2\frac{1}{16}$"
5" O.D.
$\frac{5}{8}$" O.D.
$\frac{1}{16}$"
To Reflux Condenser
Removable Adapter
$\frac{3}{8}$" O.D. Brass Tubing
$\frac{1}{32}$"
$\frac{3}{8}$" O.D. Brass
$1\frac{7}{8}$"
$\frac{29}{32}$"
$\frac{5}{8}$"
$\frac{1}{32}$"
$\frac{1}{32}$"
2"
Bath and Air Preheater
Cotton or Glass Wool Filter
30-Mesh Copper Screen
$1\frac{1}{32}$"
$2\frac{3}{4}$"
$4\frac{1}{2}$"
1" O.D.
Beaker
$\frac{1}{16}$" Brass
$\frac{3}{8}$"
$2\frac{1}{16}$" I.D.
$3\frac{5}{8}$" Dia.
$\frac{9}{16}$"
Heater
$\frac{5}{16}$" O.D. Copper Tubing $\frac{1}{32}$" Wall
Silver Solder All Joints.
Flow Meter, not drawn to scale
To Air Supply

FIG. 1.—Apparatus for Determining Gum Content of Gasoline.

Procedure

3. (*a*) The test beaker together with a similar tare beaker shall be washed free from gum with a mixture of equal volumes of benzol and alcohol, immersed for at least 12 hr. in chromic-acid cleaning solution and washed thoroughly first with tap water and then with distilled water. Subsequent to removal from the cleaning mixture the beakers shall be handled only by means of a clean, dry, metallic

holder. After washing, both beakers shall be dried thoroughly by heating to about 302 F. (150 C.), and then allowed to cool simultaneously for the same period of time, but not less than 1 hr. in a desiccator. If the air in the balance to be used is dried with a desiccant then this same desiccant shall be used in the desiccator; otherwise no drying agent shall be used in the desiccator. The test beaker shall then be weighed, using its tare (Note) on the opposite balance pan. After weighing, the tare beaker shall be replaced in the desiccator and the test beaker shall be placed in the well of the bath as shown in Fig. 1. The air flow shall be adjusted to a rate at the point of measurement of 1 liter per second ± 15 per cent. The bath shall then be heated so that the temperature of the effluent air, measured by a thermometer placed on the bottom of the beaker at the center, shall be from 305 to 320 F. (151.7 to 160 C.). This is governed largely by the rate of boiling of the bath liquid and the rate of air flow.

NOTE.—For routine tests it is permissible to use the same beaker as a tare for more than one test beaker but not for more than six test beakers, provided all are heated at the same time.

(*b*) The conical adapter shall be removed and 50 ml. of the gasoline poured into the beaker after which the adapter shall be replaced on the air outlet so that it is vertically above the center of the surface of gasoline. After the gasoline has evaporated, which should require from 8 to 14 minutes, the beaker shall be left in place for an additional 15 minutes, the air supply being maintained. During this 15-minute period the tare beaker shall also be heated to about 302 F. (150 C.). Both test and tare beakers shall then be allowed to cool simultaneously and for the same period of time, but not less than 1 hr., in a desiccator under the same conditions as prescribed in Paragraph (*a*), and the test beaker weighed as before the test. The increase in weight of the test beaker represents the amount of gum in the sample.

Results

4. Duplicate determinations shall be made and results shall be expressed in milligrams of gum per 100 ml. of gasoline.

Accuracy

5. Results obtained by different operators in different laboratories should not differ by more than the following values:

For gum contents of	0 to 20 mg. per 100 ml.	4 mg.
For gum contents of	20 to 100 mg. per 100 ml.	10 mg.
For gum contents above	100 mg. per 100 ml.	20 mg.

Duplicate results obtained by a single operator should not differ by more than one-half the above values.

TENTATIVE METHOD OF TEST
FOR
KNOCK CHARACTERISTICS OF MOTOR FUELS[1]

A.S.T.M. Designation: D 357 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1933; Revised, 1934.

Scope

1. This method is intended for determining the knock characteristics, in terms of an arbitrary scale of octane numbers, of gasolines and equivalent fuels for use in spark-ignition engines, other than engines for aircraft.

A.S.T.M. Octane Number

2. The A.S.T.M. octane number of a motor fuel is the whole number nearest to the octane number (Note 1) of that mixture of *iso*octane with normal heptane which the motor fuel matches in knock characteristics when compared by the procedure specified herein.

Note 1.—Octane number is defined by and is numerically equal to the percentage by volume of *iso*octane (2,2,4-trimethylpentane) in a mixture of *iso*octane and normal heptane, used as a primary standard for measurement of knock characteristics. Thus, by definition, normal heptane has an octane number of zero and *iso*octane of 100.

APPARATUS

Apparatus

3. The knock-testing unit described in this section shall be used without modification. The engine shall be known as the "C.F.R. Engine" and shall be marked[2] by plate or other approved

---

[1] This method heretofore known as the C.F.R. Motor Method is based on the apparatus and procedure developed by the Cooperative Fuel Research Committee, composed of representatives of the American Petroleum Institute, National Automobile Chamber of Commerce, Society of Automotive Engineers and U. S. Bureau of Standards, who have been studying this problem since 1928.

Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

[2] At present the sole authorized manufacturer of the C.F.R. Engine is the Waukesha Motor Co., Waukesha, Wis. Other manufacturers may be approved in the future, but testing laboratories should not purchase engines except from Waukesha Motor Co. without ascertaining whether such engines have been approved. Inquiries in this connection should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 50 West 50th St., New York City.

means with a combination of the respective emblems of the American Society for Testing Materials and the Cooperative Fuel Research Committee, thus.

ASTM CFR

The apparatus shall consist of a continuously-variable-compression motor together with suitable loading and accessory equipment as follows:

(*a*) *Engine.*—Continuously-variable-compression, one-cylinder, with dimensions as follows:

Bore, in.	3.25
Stroke, in.	4.50
Displacement, cu. in.	37.4
Valve diameter, in. clear	1.1875
Connecting-rod bearing:	
diameter, in.	2.25
length, in.	1.625
Front main bearing:	
diameter, in.	2.25
length, in.	2.00
Rear main bearing:	
diameter, in.	2.25
length, in.	4.25
Piston pin, floating, diameter, in.	1.25
Connecting rod, center to center, in.	10.00
Timing gear face, in.	1.00
Piston rings, number	5
Exhaust pipe, diameter, in.	1.25
Spark plug, size, mm	18.00
Weight of engine, lb. (approximate)	475
Weight of complete unit, lb. (approximate)	1375

(*b*) *Crankshaft.*—Fully machined, heat-treated, and counterbalanced.

(*c*) *Crankcase.*—Cast iron, with rigid end walls.

(*d*) *Connecting Rod.*—Rifle-drilled, S.A.E. No. 1045 steel, heat-treated, bearing alloy cast directly into big end.

(*e*) *Main Bearings.*—Renewable sleeve bushings, babbitt-lined.

(*f*) *Valves.*—Silcrome. Inlet valve with specially designed shroud.

(*g*) *Push Rods.*—Mushroom type with lock-nut adjustment.

(*h*) *Cylinders.*—Cast of iron alloy, bored and honed, Brinell hardness, 200 to 210.

(*i*) *Cylinder Head.*—Integral with cylinder.

(*j*) *Cooling System.*—Evaporatively cooled.

(*k*) *Lubrication.*—Pressure feed to main connecting-rod, piston-pin, and camshaft bearings, and to idler gear stud and gears.

(*l*) *Oil Heater and Thermometer.*—Electric heater in base to bring oil to operating temperature quickly, and a thermometer on the instrument panel to indicate when equilibrium temperature has been reached.

(*m*) *Ignition.*—May be either a battery system or a magneto. A neon-tube spark indicator is built into the engine. Spark advance is automatically adjusted as the compression ratio is changed.

(*n*) *Carburetor.*[1]—A special C.F.R. carburetor is furnished with the engine, and can be obtained with either two or three float bowls. The carburetor has a fixed fuel jet, and each float bowl is individually adjustable for level with respect to the jet for varying mixture ratio. Fuel containers are furnished with the carburetor.

(*o*) *Mixture Heater.*—As supplied by manufacturer, consisting of (*1*) a manifold, (*2*) an electric immersion heater and rheostat for controlling mixture temperature and (*3*) a special mercury-stem thermometer, 100 to 400° F. (38 to 204° C.), so mounted that the bulb is centered in the mixture stream to indicate the mixture temperature.

(*p*) *Instruments.*—Knock intensity is measured by a bouncing pin, in conjunction with a knockmeter. (The knockmeter is a damped hot-wire ammeter which indicates the effective current in the circuit, thus permitting instantaneous readings.) Current is supplied from a small direct-current generator, belt-driven from the power-absorbing unit.

(*q*) *Power-Absorbing Unit.*—The engine is connected by V-type belts to an electric generator. This preferably should be an induction motor with synchronous characteristics but may be any electric generator capable of maintaining proper operating conditions. In most cases the electric generator will act as a starting motor to crank the engine, but if a direct-current generator is used and no outside source of current is available, the engine may have to be cranked by hand.

(*r*) *Complete Unit.*—The complete unit may be obtained with the engine, generator, and panel board mounted on a cast-iron base plate. All necessary instruments and accessories are furnished with the unit.

---

[1] The use of knock-testing apparatus equipped with the carburetor described in the 1933 edition of the method (*Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 746 (1933); also 1933 Book of A.S.T.M. Tentative Standards, p. 540) is permissible.

Foundation

4. The foundation shall be of concrete and at least 18 in. high. If possible, it should be prepared by pouring on a concrete floor. Proper dimensions will be furnished with the engine. For convenience in operation, the foundation should be placed at least 2 ft. from any wall. Should the floor of the building on which the engine is to be installed be other than portland-cement concrete, the floor should be cut away so that the engine foundation will rest directly on the ground. In such case the bearing area of the foundation will depend upon the condition of the underlying soil and should be such as to give ample footing.

Reference Fuels

5. *Primary Reference Fuels.*—The primary[1] reference fuels shall be *iso*octane (2,2,4-trimethylpentane), and normal heptane (Note 1). Both shall be certified for suitability as primary reference fuels by the U. S. Bureau of Standards (Note 2).

NOTE 1. *Secondary Reference Fuels.*—Mixtures of normal heptane and *iso*octane required for referee testing are expensive. For this reason secondary reference fuels may be used for routine determinations.[2] Such secondary reference fuels may be straight-run or other stable gasolines suitable for the purpose. One of the reference fuels should be of low knock rating and the other of high knock rating, or if a sufficiently high-knock-rating fuel is not available, a mixture of the higher-knock-rating fuel plus a knock suppressor may be used. These secondary reference fuels shall be calibrated on the octane-number scale against normal heptane and *iso*octane sufficiently often to insure accuracy of calibration; and for every case, whether a fuel is rated by secondary reference fuels or by means of normal heptane and *iso*octane, the result shall be recorded as an octane number.

NOTE 2.—For the present this certification consists of tests made by the Bureau of Standards on each batch of normal heptane or *iso*octane prepared respectively by the two companies mentioned[1], with certificates issued to these companies authorizing them to guarantee to the purchaser that the material shipped is a part of a batch so tested and to quote the results of the Bureau of Standards' tests.

Standard Operating Conditions

6. The engine shall be run under the following standard conditions:

(*a*) *Engine Speed.*—900 r.p.m. ±3 r.p.m.

(*b*) *Jacket Temperature.*—Constant within ±1° F. (0.6° C.) and at a temperature between the limits of 205 and 215° F. (96 and 102° C.).

---

[1] At present, *iso*octane may be obtained from Rohm & Haas Co., 222 W. Washington Square, Philadelphia, Pa., and normal heptane from the California Chemical Co., 220 Bush Street, San Francisco, Calif.

[2] Such secondary reference fuels are commercially available through the Standard Oil Company of New Jersey with calibration curves as determined by the supplier in accordance with this method, giving octane numbers for these fuels blended with each other and with benzene and tetraethyl lead. They may be ordered from the Standard Oil Development Co., 26 Broadway, New York City.

(*c*) *Cooling Liquid.*—Distilled water, rain water, or ethylene-glycol solution when necessary at high altitude.

(*d*) *Crankcase Lubricating Oil.*—S. A. E. 30.

NOTE.—The viscosity range of crankcase lubricating oil, S.A.E. 30, is from 185 to 255 seconds when determined on the Saybolt Universal viscosimeter at 130° F. (54.4° C.), in accordance with the Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (A.S.T.M. Designation: D 88) of the American Society for Testing Materials.[1]

(*e*) *Oil Pressure.*—25 to 30 lb. per sq. in. under operating conditions.

(*f*) *Valve Clearances.*—Intake 0.008 in., cold; exhaust 0.010 in., cold.

(*g*) *Spark Advance.*—Automatically controlled:

26.0 deg. at 5:1 compression ratio (basic setting);
22.0 deg. at 6:1 compression ratio;
19.0 deg. at 7:1 compression ratio.

(*h*) *Breaker-Point Clearance.*—Battery system 0.015 in.; magneto 0.020 in.

(*i*) *Spark Plug.*—Shall conform to the standard metric plug having the tolerances and thermal characteristics equal to the No. 8 spark plug furnished by the Champion Spark Plug Co., Toledo, Ohio. Gap setting, 0.025 in.

(*j*) *Throttle Opening.*—All tests shall be conducted with the throttle opening at the point of maximum volumetric efficiency, approximately 90 on the throttle scale.

(*k*) *Carburetor Adjustment.*—For maximum knock.

(*l*) *Exhaust Pipe.*—A separate exhaust pipe should be used for each engine. This pipe should be made from $1\frac{1}{4}$-in. pipe having a maximum of two ells with a total length not to exceed 20 ft. The use of a short straight-through muffler of $1\frac{1}{4}$-in. diameter passage for prevention of noise is permissible.

(*m*) *Mixture Temperature.*—The mixture temperature shall be maintained at 300° F. ±2° F. (149° C. ±1.1° C.) as indicated by the mercury stem thermometer.

(*n*) *Bouncing Pin Assembly.*—The gap setting shall be 0.003 in. to 0.005 in.

NOTE.—The following instructions for setting of the bouncing-pin contacts should be used: With the daily inspection, observe the contact points and electrical connections to see that the points are smooth and that all the connections are tight. The gap setting should be checked (0.003-in. to 0.005-in.). The flat spring of the lower contact should touch the insulated pin with slight pressure. Too much pressure will reduce its sensitivity. To adjust the pressure accurately, set the points with 0.003-in. to 0.005-in. clearance. Then remove the diaphragm and bouncing pin. Bend the lower spring until there is from $\frac{3}{64}$-in. to $\frac{1}{16}$-in. gap between the points. Remove the upper stop-adjusting screw and bend the upper spring until there is $\frac{5}{32}$-in. gap between the points. Check the tension on the small plunger spring in upper stop-adjusting screw and see that it has from 1- to $1\frac{1}{4}$-lb. initial tension. This can be measured by pressing it against any convenient platform scale. The pin should then be re-assembled and the adjusting screw set to give 0.003-in. to 0.005-in. gap between the points. The final adjustment is made by setting the clearance so that a knockmeter reading between 50 and 60 is obtained when operating the engine at the proper knock intensity.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 880.

PROCEDURE

Starting and Stopping the Engine

7. While the engine is being turned over by electric motor the ignition shall be turned on and the carburetor set so as to draw fuel from one float bowl. To stop the engine the fuel and the ignition switch shall be turned off and then the motor shall be stopped by means of the push-button switch. To avoid corrosion of valves and seats between operating periods the engine should be turned over by hand until both valves are closed.

Preliminary Adjustment of Compression Ratio

8. Using a mixture of 65 parts of *iso*octane and 35 parts of normal heptane, the compression ratio for first audible knock shall be obtained by increasing the compression ratio, by increments of two turns of the crank, from a point where there is no knock to the compression ratio at which audible knock is first detected. The proper knock intensity for use in making knock ratings shall be the knock intensity obtained with the mixture of 65 parts of *iso*octane and 35 parts of normal heptane when the compression ratio is increased one unit over that compression ratio giving first audible knock. Then the numerical indication of knock intensity obtained from the knockmeter shall be recorded. This procedure is necessary for the first adjustment only.

NOTE.—This knock intensity should be equivalent to the intensity obtained with a mixture of 65 per cent of *iso*octane and 35 per cent of normal heptane at a compression ratio of 5.3 ± 0.05 to 1 when testing at a barometric pressure of 760 mm.

For subsequent tests on fuel samples the compression ratio shall be set to duplicate the knock intensity as recorded above, provided no change has been made in the bouncing-pin adjustment in the meantime. In no case shall the knock intensity be such that the engine does not cease firing when ignition is interrupted.

Outline of Procedure

9. The octane number of a fuel shall be ascertained by comparing the knock intensity for the fuel with those for various blends of the reference fuels until two blends differing in knock rating by not more than two octane numbers are found, one of which gives a higher knock intensity than the fuel and the other a lower knock intensity. The knock intensity shall be measured by a bouncing-pin indicator in conjunction with a knockmeter.

Before the test sample and the blends of the reference fuels can be compared, the compression ratio must be set to give the proper knock intensity and the carburetor adjusted to give the maximum knock for each fuel.

Adjustment of Carburetor for Test Fuel

10. Using the fuel whose knock rating is to be determined, the carburetor shall be adjusted as follows: After one float bowl of the carburetor has been filled with the fuel of which the octane number is to be determined, adjustment shall be made to obtain maximum knock by raising and lowering the level of the float bowl and noting whether the knockmeter reading increases or decreases. The float bowl shall then be moved in the direction in which the knock increases until the knock passes through a maximum. This point shall be checked three times and the float bowl set at the position of maximum knock. The knockmeter needle shall be allowed to reach equilibrium after each adjustment of the float-bowl level.

Final Adjustment of Compression Ratio

11. Finally, adjust the compression ratio to give the same reading on the knockmeter when using the fuel under test as was obtained in the first adjustment under Section 8.

12. A trial blend[1] of the low-octane-number reference fuel and the high-octane-number reference fuel, based on the expected knock rating of the fuel sample under test, shall be placed in another carburetor float bowl and the engine run on this trial blend. The level of this float bowl shall then be adjusted to the maximum knock position in a manner similar to that described in Section 10.

Octane Number Determination

13. With the carburetor set for the air-fuel ratio of maximum knock, alternate series of readings of knock intensity shall be taken on the fuel under test and on a reference fuel blend. The knockmeter needle shall be allowed to reach equilibrium before the final reading is recorded.

---

[1] Extreme care is required to insure thorough mixing of ingredients.

At least 3 alternate series of readings shall be taken on each fuel. After changing from one fuel to another, at least 1 minute shall be allowed for the engine to reach equilibrium. With some fuels an appreciably longer time interval may be required. If the average knock intensity of the fuel sample is higher than the average of the reference fuel blend, the test shall be repeated with a blend containing a decreased proportion of the high-octane-number reference fuel.[1] The test shall be continued in this manner until the knock intensity for the fuel sample is definitely higher than one blend and lower than another blend of the reference fuels. The difference between these two final reference fuel blends shall be not more than two octane numbers.

CALCULATION

Calculation

14. The knock rating of the fuel sample shall be obtained by interpolation from the figures so recorded and the nearest whole number shall be reported as A.S.T.M. octane number.

Check of Test Conditions

15. Test conditions shall not be regarded as standard unless a blend by volume of 65 per cent *iso*octane and 35 per cent normal heptane is matched under the specified procedure by a blend by volume of 68 ±1 per cent one-degree benzene with 32 ±1 per cent normal heptane. At atmospheric pressure of 760 mm. a compression ratio of approximately 5.3:1 is correct for this determination. Substantial variations in atmospheric pressure will change the compression ratio required.

NOTE 1.—For routine checking purposes, one-degree benzene and secondary reference fuels may be used.

NOTE 2.—"One-degree" benzene[2] is a commercial product conforming to the following requirements:

(*a*) Boiling range not greater than 1° C., embracing the boiling point of chemically pure benzene.

(*b*) Specific gravity of from 0.882 to 0.886, when determined in accordance with the Standard Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (A.S.T.M. Designation: D 287) of the American Society for Testing Materials.[3]

(*c*) Free from hydrogen sulfide, carbon disulfide and thiophene.

(*d*) Free from turbidity, with color not darker than a solution of 3 mg. of potassium dichromate in 1 liter of water when compared in 50-ml. Nessler tubes.

---

[1] When changing fuels in the containers, the fuel in the container shall be drained completely by means of the drain-cock provided. A small portion of the new fuel shall be allowed to flow through the line before closing the drain-cock.

[2] "One-degree" benzene may be procured from The Barrett Co., 40 Rector St., New York City.

[3] 1933 Book of A.S.T.M. Standards, Part II, p. 819.

ACCURACY

Accuracy

16. Results obtained by this procedure with different C. F. R. engines and in different laboratories should differ by not more than two octane numbers.

While the accuracy of this method is as above stated, its sensitivity may permit detection of differences as small as 0.2 octane number when alternate readings of knock intensity are taken on the two fuels as directed in Section 13.

MAINTENANCE

Maintenance

17. It is recommended that a systematic inspection of the testing apparatus be carried out with the utmost care after each 50 hours of operation. The following points should be emphasized:

(*a*) *Bouncing Pin.*—Lack of sensitivity, fluctuating knockmeter reading, or irregular gas evolution may indicate diaphragm trouble. The diaphragm retaining nut should be tightened and any carbon accumulation removed. If this does not correct the condition, the diaphragm may have deteriorated and may need to be replaced.

(*b*) *Breaker Points.*—If necessary, pits should be removed and breaker-point clearance adjusted.

(*c*) *Spark Plugs.*—The porcelain should be carefully inspected for cracks, and defective plugs replaced. The spark gap shall be carefully checked and adjusted if necessary. When plugs are re-used any carbon deposit on the metal body of the plug or on the electrodes shall be removed mechanically before making gap adjustments.

(*d*) *Fuel System.*—Any foreign matter in the fuel containers, float bowls, lines, or carburetor shall be removed. Blowing with air and then flushing the fuel system with gasoline or benzol is a convenient method.

(*e*) *Cooling System.*—Any leaks revealed by inspection shall be repaired.

(*f*) *Combustion Chamber.*—Carbon deposits shall be removed by scraping.

(*g*) *Compression Pressure.*—The cause of any abnormal change between inspections shall be investigated and corrected.

(*h*) *Valves.*—Valves shall be removed and reground unless there is a continuous polished line of contact on both the valve and the valve seat. After reassembling, the valve-tappet clearances shall be carefully adjusted.

(*i*) *Piston Rings.*—Carbon shall be removed from rings and grooves.

(*j*) The intake manifold and heater blades shall be inspected and cleaned if necessary.

TENTATIVE METHOD OF TEST

FOR

SULFUR IN PETROLEUM OILS BY LAMP METHOD[1]

A.S.T.M. Designation: D 90 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1921; REVISED, 1924, 1926, 1929, 1930, 1934.

Scope.

1. This method shall be used for the determination of sulfur in kerosine, petroleum naphtha, and other petroleum oils which can be burned completely in a wick lamp. This method may be applied to motor fuels which are mixtures of gasoline and volatile non-petroleum oils.

NOTE.—When this method is applied to mixtures containing carbon bisulfide approximately 85 per cent of the sulfur present as carbon bisulfide is usually determined.

APPARATUS

Apparatus.

2. The apparatus shall consist of the following:

(*a*) *Absorber.*—An absorber of chemically-resistant glass conforming to the dimensions shown in Fig. 1. The larger of the two bulbs of the absorber shall be filled at least two-thirds full with pieces of chemically-resistant glass rod from 8 to 10 mm. in length and from 5 to 6 mm. in diameter, or with perforated beads of chemically resistant glass 5 to 8 mm. in diameter.

(*b*) *Chimney.*—A chimney of chemically-resistant glass conforming to the dimensions shown in Fig. 1, and connected with the absorber by a cork stopper.

(*c*) *Spray Trap.*—A spray trap of chemically-resistant glass conforming to the dimensions shown in Fig. 1, and connected with the absorber by a cork or by a rubber stopper.

(*d*) *Lamp.*—A small lamp of about 25-ml. capacity. The lamp may conveniently consist of a 25 to 35-ml. Erlenmeyer flask, preferably of the shape shown in Fig. 1, and a cork carrying a piece of

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-2 on Petroleum Products and Lubricants.

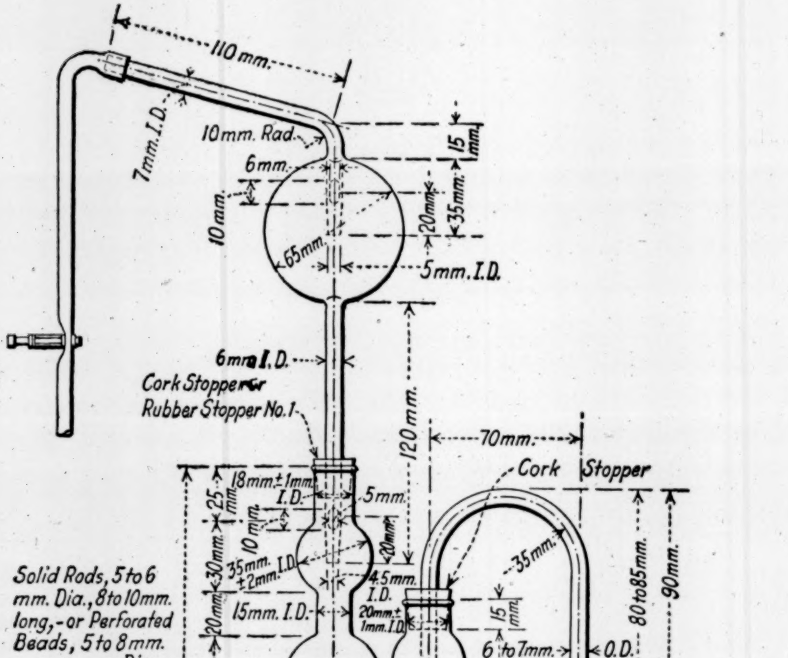

110 mm.
7mm. I.D.
10mm. Rad.
15 mm.
6mm.
10 mm.
20mm.
35mm.
65mm.
5mm. I.D.
6mm I.D.
Cork Stopper or Rubber Stopper No. 1
120 mm.
70mm.
Cork Stopper
18mm.±1mm. I.D.
5mm.
25 mm.
10 mm.
20mm.
30mm.
35mm. ±2mm. I.D.
4.5mm. I.D.
35mm.
15 mm.
80 to 85mm.
90mm.
Solid Rods, 5 to 6 mm. Dia., 8 to 10mm. long, - or Perforated Beads, 5 to 8 mm. Dia.
20mm.
15mm. I.D.
20mm.± 1mm. I.D.
6 to 7mm.
O.D.
45 mm. ±2mm. I.D.
5mm. max
35mm.± 2mm. I.D.
227 mm.
125 mm.
6 mm.±1 mm.
125 mm.
16 to 18 mm. I.D.
115mm.
Top of Tube not more than 1 or 2 mm. above Base of Chimney.
Cork Stopper with Vertical Triangular Groove for Air Vent.
27mm.
27mm.
O.D. 8 to 9 mm.
I.D. 4 to 5 mm.
8 to 9 mm.
40mm.
Glass Tube 6 to 7 mm. O.D., 3.0mm. I.D., 40 mm. long.
Clean Cotton Wicking 10 to 12 cm. long. Two Strands weighing 5 to 6 mg. per cm. per Strand.
Set Screw with Fiber Tip

FIG. 1.—Apparatus for Determination of Sulfur in Oils.

NOTE.—In the case of those dimensions for which no specific tolerances are designated above, the permissible variation is ± 10 per cent to the nearest millimeter, provided, however, that in no case the deviation be greater than 5 mm.

glass tubing 40 mm. in length, from 6 to 7 mm. in outside diameter. and 3 mm. in inside diameter, with ends ground or fused level, The wick tube should project above the cork at least 10 mm., and the cork shall have a vertical groove in its side so that air may enter the flask to replace the oil as it is consumed.

(*e*) *Cotton Wicking.*—Two strands of clean, unused cotton wicking, 10 to 12 cm. in length and weighing about 5 to 6 mg. per cm. per strand.

(*f*) *Filter Pump.*—A filter pump or other means for continuous suction.

SOLUTIONS REQUIRED

Solutions Required.

3. (*a*) *Hydrochloric Acid.*—Prepare a solution of HCl in distilled water which will contain 2.275 g. of HCl per liter and check carefully for accuracy.

(*b*) *Sodium Carbonate.*—Dissolve 3.306 g. of Na_2CO_3 in one liter of distilled water. Ten cubic centimeters of this solution should neutralize exactly 10 ml. of the HCl solution.

(*c*) *Methyl Orange.*—Dissolve 0.004 g. of methyl orange in one liter of distilled water.

PROCEDURE

Procedure.

4. The sulfur shall be determined as follows:

(*a*) Pass two strands of the new cottom wicking through the wick tube so that they are not twisted but are parallel in the wick tube. Pour into the clean, dry lamp about 15 ml. of the oil to be tested, and insert the cork containing the wick tube. After the wick has become saturated with the oil, trim it off as nearly as possible to the top of the wick tube with a pair of sharp scissors, finally adjusting the wick height by touching the top of it with the tip of a finger. Weigh the oil and lamp assembly to the nearest 0.001 g. Run a blank determination at the same time and under the same conditions by burning sulfur-free alcohol in a similar lamp. Thoroughly rinse out the absorber with distilled water, and put into it exactly 10 ml. of the sodium carbonate solution from an accurately calibrated pipette, and then dilute the solution with 10 ml. of distilled water. Rinse out also the chimney and the spray trap with distilled water, dry the chimney, and connect both to the absorber as shown in Fig. 1. Prepare the apparatus for the blank determination in the same manner putting into it exactly 10 ml. of the sodium carbonate solution and 10 ml. of distilled water. Apply gentle suction to both absorbers; light both the oil lamp and the alcohol lamp and then place them in position under the chimneys so that the top of each wick tube extends into the chimney not more than 1 or 2 mm. above the edge. Use a sulfur-free flame, such as an alcohol lamp for lighting the lamps; do not use matches. Adjust the suction so that a steady flame 12 to 18 mm. in height and free from smoking is obtained (Note 1). The suction shall be adjusted so that air is drawn through both absorbers at approximately the same rate. The maintenance of proper flame height usually requires that the wick be flush with the top of the wick tube for naphthas or motor fuels and a little higher for illuminating oils. The room shall be free from draughts. Continue burning for from one to one and one-half hours, or less if the sulfur content of the oil is high. During this time the oil should be consumed at the rate of about 2 to 2.5 g. per hour.

(*b*) Extinguish the flames and stop the suction on both absorbers. Weigh the oil lamp immediately to the nearest 0.001 g., and determine by difference the weight of oil consumed. Working with the blank first, disconnect the spray trap and chimney and wash them thoroughly with the methyl orange solution, using a wash bottle with a very fine jet and collecting the washings in the absorber. Use approximately 35 ml. of the solution for washing. Carefully titrate the faintly-yellow solution with the HCl solution. During titration, carefully agitate the contents of the absorber either by alternate sucking and blowing through a rubber tube held between the lips, or else by the use of a suitable rubber-syringe bulb. As the end point is approached, draw the liquid back and forth between the bulbs after each addition of acid, agitating as before When the first permanent pink color appears, the end point has been reached. Read and record the volume of HCl solution used (Note 2).

(*c*) Rinse the chimney and the spray trap used in the actual determination into the absorber to which they were connected, exactly as has been prescribed for the blank. If at this point the solution in the absorber should have a pink color, too much oil has been burned and the determination shall be repeated, but burning for a shorter time. The temporary pink color that sometimes appears in the chimney when rinsing it out should be disregarded. Titrate just as in the blank, continuing to add the HCl solution until the color matches that obtained in the blank. Read and record the volume of HCl solution used.

NOTE 1.—If it is not possible to obtain a good flame free from smoking, as sometimes happens if the oil contains considerable percentages of benzol, dilute the oil with an equal weight of sulfur-free anhydrous alcohol before putting the sample into the lamp. If, while maintaining the specified flame height the flame still smokes, a smaller flame is permissible. In order to get the correct value when calculating the percentage of sulfur present in this case, allowance shall be made for the fact that the sample as burned in the lamp is one-half alcohol. This shall be done by doubling the percentage of sulfur obtained in computation by the formula given in Section 5.

NOTE 2.—For accurate work, conditions shall be such that a minimum or zero blank is obtained. If the titration of the blank requires more than 0.1 ml. of the HCl solution per gram of sample burned, which corresponds to 0.01 per cent of sulfur, a high degree of accuracy cannot be expected in the case of oils of low sulfur content.

5. Calculate the sulfur content of the oil by substituting the proper values in the following formula: **Calculation.**

$$\text{Percentage of sulfur} = \frac{\begin{matrix}\text{milliliters} \\ \text{of HCl for blank}\end{matrix} - \begin{matrix}\text{milliliters} \\ \text{of HCl for sample}\end{matrix}}{\text{grams of oil burned} \times 10}$$

This formula is correct only for the standard solutions specified in Section 3, 1 ml. of each being equivalent to 0.001 g. of sulfur. The use of solutions of any other strength, such as 0.1 *N*, involves more complicated calculation and is not advisable.

6. As a check on the determination, a sample of known sulfur content shall be analyzed. Such a reference sample may be made by adding a pure volatile sulfur compound, such as carbon bisulfide, to sulfur-free anhydrous alcohol. This check shall indicate from 85 to 100 per cent of the sulfur present. **Check Determination.**

7. Duplicate determinations by the same operator should not differ by more than the amounts given in the following tabulation: **Accuracy.**

SULFUR FOUND, PER CENT	AVERAGE DEVIATION FROM MEAN, PER CENT SULFUR
Under 0.125	0.0025
0.125 to 0.25	0.005
0.25 to 0.50	0.01
Over 0.50	0.02

For different operators corresponding deviations may be double those given above.

TENTATIVE SPECIFICATIONS
FOR
EMULSIFIED ASPHALT[1]
(FOR COARSE AGGREGATE PLANT MIXES)

A.S.T.M. Designation: D 397 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Properties and Tests

1. (*a*) Emulsified asphalt shall be homogeneous. It shall show no separation of asphalt after thorough mixing, within 30 days after delivery, provided separation has not been caused by freezing.

(*b*) Emulsified asphalt for coarse aggregate plant mixes shall conform to the following requirements:

Viscosity, Saybolt Furol, 60 ml. at 25 C. (77 F.)	not less than 100 sec., and not more than 700 sec.
Residue by distillation	not less than 60 per cent, and not more than 65 per cent
Settlement, 5 days	not more than 5 per cent
Demulsibility,[a] 50 ml. of 0.1 N $CaCl_2$	not more than 30 per cent
Sieve test	not more than 0.10 per cent
Miscibility with water	no appreciable separation in 2 hr.
Coating test	it shall not show appreciable separation when mixed with washed, dry, clean stone for 3 min. and shall coat the stone thoroughly.

---

[a] The demulsibility test shall be made within 30 days from date of shipment.

(*c*) *Residue.*—The residue obtained from distillation shall conform to the following requirements:

Penetration at 25 C. (77 F.), 100 g., 5 sec	100 to 200
Soluble in carbon disulfide	not less than 95 per cent
Ash	not more than 2 per cent
Ductility at 25 C. (77 F.)	not less than 40 cm.
Specific gravity at 25 C. (77 F.)	not less than 1.00

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

Basis of Purchase

2. Prior to the award of the order or contract, a sample may be tested by the purchaser and if it fails to comply with the specification requirements, the bid accompanying the sample shall be rejected. The sample shall be taken under the supervision of the purchaser, from factory storage containing not less than 20,000 gal. of the emulsified asphalt and shall be kept in a clean air-tight sealed container at a temperature of not less than 4 C. (40 F.) until tested.

Sampling

3. At least one sample of not less than 1 gal. shall be taken from each lot or shipment of the emulsified asphalt after arrival at its destination. The samples shall be stored in clean air-tight containers at a temperature of not less than 4 C. (40 F.) until tested.

Methods of Testing

4. The properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Test for Emulsified Asphalts (A.S.T.M. Designation: D 244 - 34 T) of the American Society for Testing Materials.[1]

---

[1] See p. 926.

TENTATIVE SPECIFICATIONS
FOR
EMULSIFIED ASPHALT[1]
(FOR RETREAD AND COARSE AGGREGATE MIXES)

A.S.T.M. Designation: D 398 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Properties and Tests

1. (*a*) Emulsified asphalt shall be homogeneous. It shall show no separation of asphalt after thorough mixing, within 30 days after delivery, provided separation has not been caused by freezing.

(*b*) Emulsified asphalt for retread and coarse aggregate mixes shall conform to the following requirements:

Viscosity, Saybolt Furol, 60 ml. at 25 C. (77 F.)	not less than 20 sec., and not more than 100 sec.
Residue by distillation	not less than 55 per cent, and not more than 60 per cent
Settlement, 5 days	not more than 5 per cent
Demulsibility,[a] 50 ml. of $0.1\,N$ $CaCl_2$	not more than 30 per cent
Sieve test	not more than 0.10 per cent
Miscibility with water	no appreciable separation in 2 hr.
Coating test	it shall not show appreciable separation when mixed with washed, dry, clean stone for 3 min. and shall coat the stone thoroughly.

[a] The demulsibility test shall be made within 30 days from date of shipment.

(*c*) *Residue.*—The residue obtained from distillation shall conform to the following requirements:

Penetration at 25 C. (77 F.), 100 g., 5 sec	100 to 200
Soluble in carbon disulfide	not less than 95 per cent
Ash	not more than 2 per cent
Ductility at 25 C. (77 F.)	not less than 40 cm.
Specific gravity at 25 C. (77 F.)	not less than 1.00

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

Basis of Purchase

2. Prior to the award of the order or contract, a sample may be tested by the purchaser and if it fails to comply with the specification requirements, the bid accompanying the sample shall be rejected. The sample shall be taken under the supervision of the purchaser, from factory storage containing not less than 20,000 gal. of the emulsified asphalt and shall be kept in a clean air-tight sealed container at a temperature of not less than 4 C. (40 F.) until tested.

Sampling

3. At least one sample of not less than 1 gal. shall be taken from each lot or shipment of the emulsified asphalt after arrival at its destination. The samples shall be stored in clean air-tight containers at a temperature of not less than 4 C. (40 F.) until tested.

Methods of Testing

4. The properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Test for Emulsified Asphalts (A.S.T.M. Designation: D 244 - 34 T) of the American Society for Testing Materials.[1]

---

[1] See p. 926.

TENTATIVE SPECIFICATIONS
FOR
EMULSIFIED ASPHALT[1]
(HEAVY PREMIX—SUMMER GRADE)

A.S.T.M. Designation: D 399 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1934.[2]

Properties and Tests

1. (*a*) Emulsified asphalt shall be homogeneous. It shall show no separation of asphalt after thorough mixing, within 30 days after delivery, provided separation has not been caused by freezing.

(*b*) Emulsified asphalt (heavy premix - summer grade) shall conform to the following requirements:

Residue by distillation	not less than 65 per cent
Sieve test	not more than 0.10 per cent
Miscibility with water	no appreciable separation in 2 hr.
Coating test	it shall not show appreciable separation when mixed with washed, dry, clean stone for 3 min. and shall coat the stone thoroughly.

(*c*) *Residue*.—The residue obtained from distillation shall conform to the following requirements:

Penetration at 25 C. (77 F.), 100 g., 5 sec	100 to 200
Soluble in carbon disulfide	not less than 95 per cent
Ash	not more than 2 per cent
Ductility at 25 C. (77 F.)	not less than 40 cm.
Specific gravity at 25 C. (77 F.)	not less than 1.00

Basis of Purchase

2. Prior to the award of the order or contract, a sample may be tested by the purchaser and if it fails to comply with the specification requirements, the bid accompanying the sample shall be rejected. The sample shall be taken under the supervision of the purchaser, from factory storage containing not less than 20,000 gal. of the emulsified asphalt and shall be kept in a clean air-tight sealed container at a temperature of not less than 4 C. (40 F.) until tested.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

Sampling

3. At least one sample of not less than 1 gal. shall be taken from each lot or shipment of the emulsified asphalt after arrival at its destination. The samples shall be stored in clean air-tight containers at a temperature of not less than 4 C. (40 F.) until tested.

Methods of Testing

4. The properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Test for Emulsified Asphalts (A.S.T.M. Designation: D 244 – 34 T) of the American Society for Testing Materials.[1]

---

[1] See p. 926.

TENTATIVE SPECIFICATIONS
FOR
EMULSIFIED ASPHALT[1]
(HEAVY PREMIX—WINTER GRADE)

A.S.T.M. Designation: D 400 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1934.[2]

Properties and Tests

1. (*a*) Emulsified asphalt shall be homogeneous. It shall show no separation of asphalt, after thorough mixing, within 30 days after delivery.

(*b*) Emulsified asphalt (heavy premix - winter grade) shall conform to the following requirements:

Residue by distillation	not less than 65 per cent
Sieve test	not more than 0.10 per cent
Freezing test, 3 cycles	shall remain homogeneous
Miscibility with water	no appreciable separation in 2 hr.
Coating test	it shall not show appreciable separation when mixed with washed, dry, clean stone for 3 min. and shall coat the stone thoroughly.

(*c*) *Residue.*—The residue obtained from distillation shall conform to the following requirements:

Penetration at 25 C. (77 F.), 100 g., 5 sec	125 to 225
Soluble in carbon disulfide	not less than 95 per cent
Ash	not more than 2 per cent
Ductility at 25 C. (77 F.)	not less than 40 cm.
Specific gravity at 25 C. (77 F.)	not less than 1.00

Basis of Purchase

2. Prior to the award of the order or contract, a sample may be tested by the purchaser and if it fails to comply with the specification requirements, the bid accompanying the sample shall be rejected. The sample shall be taken under the supervision of the purchaser, from factory storage containing not less than 10,000 gal. of the emulsified asphalt and shall be kept in a clean air-tight sealed container until tested.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

Sampling

3. At least one sample of not less than 1 gal. shall be taken from each lot or shipment of the emulsified asphalt after arrival at its destination. The samples shall be stored in clean air-tight containers until tested.

Methods of Testing

4. The properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Test for Emulsified Asphalts (A.S.T.M. Designation: D 244 - 34 T) of the American Society for Testing Materials.[1]

---

[1] See p. 926.

TENTATIVE SPECIFICATIONS
FOR
EMULSIFIED ASPHALT[1]
((QUICK-SETTING) FOR PENETRATION AND SURFACE TREATMENT)

A.S.T.M. Designation: D 401 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Properties and Tests

1. (*a*) Emulsified asphalt shall be homogeneous. It shall show no separation of asphalt after thorough mixing, within 30 days after delivery, provided separation has not been caused by freezing.

(*b*) Emulsified asphalt (quick-setting) for penetration and surface treatment shall conform to the following requirements:

Viscosity, Saybolt Furol, 60 ml. at 25 C. (77 F.)	not less than 20 sec., and not more than 100 sec.
Residue by distillation	not less than 55 per cent, and not more than 60 per cent
Settlement, 5 days	not more than 3 per cent
Demulsibility,[a] 35 ml. of 0.02 N $CaCl_2$	not less than 50 per cent
Sieve test	not more than 0.10 per cent

(*c*) *Residue.*—The residue obtained from distillation shall conform to the following requirements:

Penetration at 25 C. (77 F.), 100 g., 5 sec	100 to 200
Soluble in carbon disulfide	not less than 95 per cent
Ash	not more than 2 per cent
Ductility at 25 C. (77 F.)	not less than 40 cm.
Specific gravity at 25 C. (77 F.)	not less than 1.00

---

[a] The demulsibility test shall be made within 30 days from date of shipment.

Basis of Purchase

2. Prior to the award of the order or contract, a sample may be tested by the purchaser and if it fails to comply with the specification requirements, the bid accompanying the sample shall be rejected. The sample shall be taken under the supervision of the purchaser, from factory storage containing not less than 20,000 gal. of the emulsi-

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

fied asphalt and shall be kept in a clean air-tight sealed glass or black iron container at a temperature of not less than 4 C. (40 F.) until tested.

Sampling

3. At least one sample of not less than 1 gal. shall be taken from each lot or shipment of the emulsified asphalt after arrival at its destination. The samples shall be stored in clean air-tight glass or black iron containers at a temperature of not less than 4 C. (40 F.) until tested.

Methods of Testing

4. The properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Test for Emulsified Asphalts (A.S.T.M. Designation: D 244-34 T) of the American Society for Testing Materials.[1]

---

[1] See p. 926.

TENTATIVE METHODS OF TESTING EMULSIFIED ASPHALTS[1]

A.S.T.M. Designation: D 244 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1926; REVISED, 1928, 1933, 1934.[2]

Scope

1. These methods are intended for the examination of asphalt emulsions composed, principally, of a semisolid or liquid asphaltic base, water and an emulsifying agent.

VISCOSITY

2. The viscosity of emulsified asphalt shall be determined by means of the Saybolt Furol viscosimeter.

Apparatus

3. The following apparatus will be required:

(*a*) *Viscosimeter*.—A Saybolt Furol viscosimeter conforming to the requirements specified in the Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (A.S.T.M. Designation: D 88) of the American Society for Testing Materials.[3]

(*b*) *Sieve*.—A No. 20 sieve of the U. S. Standard Sieve Series, of iron wire cloth, framed or unframed, optional, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[4]

Procedure

4. (*a*) The viscosity determination shall be made at 77 F. (25 C.) and shall be expressed in seconds, Saybolt Furol, being the time in seconds for the delivery of 60 ml. of emulsion.

(*b*) While the Saybolt Furol viscosimeter is not used for petroleum products and lubricants when the time of flow is less than 25 sec., this instrument is satisfactory for testing emulsified asphalt when the time of flow is not less than 20 sec.

---

[1] Under the standardization procedure of the Society, these methods are under the joint jurisdiction of A.S.T.M. Committee D-4 on Road and Paving Materials and Committee D-8 on Bituminous Waterproofing and Roofing Materials.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

[3] 1933 Book of A.S.T.M. Standards, Part II, p. 880.

[4] *Ibid.*, p. 1244.

(*c*) *Preparation of Sample.*—The sample shall be stirred thoroughly without incorporating bubbles in it and then poured into a 4-oz. bottle. The bottle shall then be placed in the water bath at 77 F. (25 C.) for 30 min. and the sample then mixed in the bottle by inverting several times, slowly enough to prevent bubble formation. The sample shall then be poured into the viscosity tube through a 20-mesh strainer, allowing a small portion to flow through the outlet tube to waste. The cork shall then be placed in position, the tube filled and without again stirring the sample the viscosity shall be determined as described in the Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (A.S.T.M. Designation: D 88) of the American Society for Testing Materials.[1]

DISTILLATION

Apparatus

5. The following apparatus will be required:

(*a*) *Iron Still.*—The iron still shall be approximately 6 by 3½ in. in inside diameter with adjustable ring burner with holes on the inner periphery to fit around the outside of the still.

NOTE.—A modification of this still is shown in Fig. 2. It consists of the regular still with an expansion chamber superimposed thereon. Two additional ring burners are required, one approximately 6 in. in inside diameter with the holes bored on the inside periphery, and one approximately 2 in. in diameter with the holes bored on top.

(*b*) *Connecting Apparatus.*—A connecting tube, tin shield, condenser trough, condenser tube and graduated cylinder, as shown in Fig. 1.

(*c*) *Thermometer.*—A thermometer graduated from 30 to 580 F. (0 to 300 C.), conforming to the requirements of the Low-Distillation Thermometer specified in the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials.[2]

NOTE.—The details of the assembly of apparatus for the distillation test are illustrated in Fig. 1.

Procedure

6. (*a*) Exactly 200 g. of a well-mixed and representative sample of the emulsion shall be placed in the previously weighed iron still (including lid, clamp, thermometer and gasket, if gasket is used).

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 880.

[2] *Ibid.*, p. 778.

(*b*) A gasket of oiled paper may be used between the still and its cover or the joint ground to a tight fit. The cover shall be clamped securely on the still.

(*c*) The thermometer shall be inserted through the small hole in the cover, using a cork stopper, so that the end of the bulb is ¼ in. from the bottom of the still.

(*d*) The ring burner shall be placed around the still and the heat applied by this means to the top of the still. Just enough heat from a bunsen burner shall also be applied to the connecting tube to prevent condensation of water in this tube.

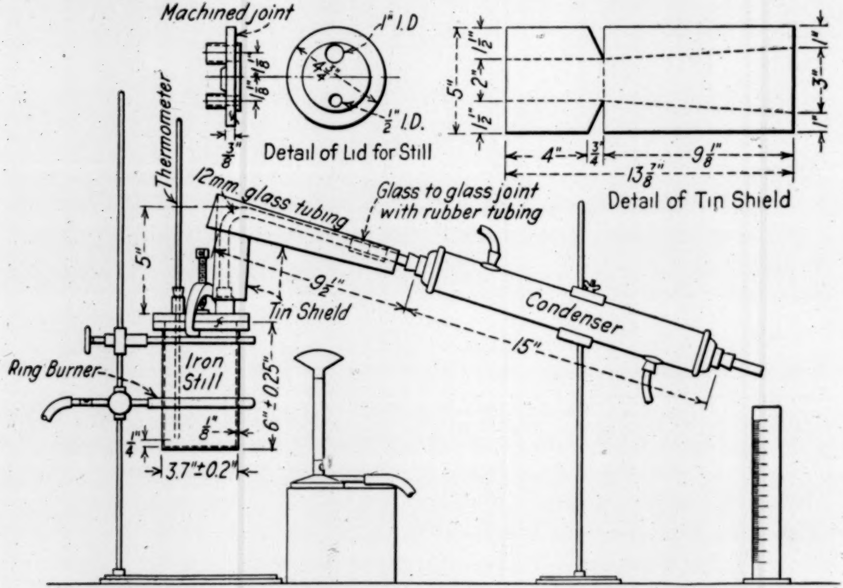

Machined joint
1" I.D
$4\frac{3}{4}$"
$\frac{1}{2}$" I.D.
$\frac{1}{8}$"
$\frac{1}{8}$"
$\frac{3}{8}$"
Detail of Lid for Still
5"
$1\frac{1}{2}$"
2"
$1\frac{1}{2}$"
1"
3"
1"
4"
$\frac{3}{4}$"
$9\frac{1}{8}$"
$13\frac{7}{8}$"
Detail of Tin Shield
Thermometer
12mm. glass tubing
Glass to glass joint with rubber tubing
5"
$9\frac{1}{2}$"
Tin Shield
Condenser
15"
Ring Burner
Iron Still
6" ± 0.25"
$\frac{1}{8}$"
$\frac{1}{4}$"
3.7" ± 0.2"

FIG. 1.—Apparatus Assembly for Distillation Test of Emulsified Asphalts.

(*e*) After practically all the condensate has been removed from the still and the temperature of the residue has reached 250 F. (121 C.), the position of the heat from the ring burner shall be lowered to midway of the still and held there until the thermometer reaches 349 F. (176 C.). The burner shall then be rapidly lowered to within ½ in. of the bottom of the still and the temperature increased to and maintained at 500 F. (260 C.) for 15 min. This latter period of heating is necessary to insure a smooth homogeneous residue in the still.

(*f*) At the expiration of the heating period at the maximum temperature, the still and accessories shall again be weighed as described in Paragraph (*a*) and the percentage residue calculated and reported. The cover shall then be removed from the still and suitable portions of the residue shall be poured immediately into suitable molds and containers for making the required tests. The residue in the molds and containers shall be permitted to cool, uncovered, to laboratory room temperature and thereafter tested as described in Sections 26 to 30, inclusive.

NOTE.—When it appears impossible to distill an emulsified asphalt in the still described in Section 5 (*a*) due to excessive foaming of the emulsion, then the modified still shown in Fig. 2 should be substituted for the still shown in Fig. 1 and the following procedure followed: Place the 6-in. burner around the larger diameter of the still near its top. This serves as a support. Place the 4-in. burner immediately beneath the flare and the 2-in. burner not less than 2 in. below the bottom. Distillation is started with only the 2-in. burner lighted. Practically all of the distillate should be over in about 45 min. When the distillation apparently stops, light the two larger ring burners and adjust to a low flame. Distillation resumes and when it stops again increase the heat by adjusting the flame of the 2-in. burner. When the temperature can be read upon the thermometer, increase the rate of heating by raising the flame on both the 2 and 4-in. burners and bring the temperature to 500 F. (260 C.).

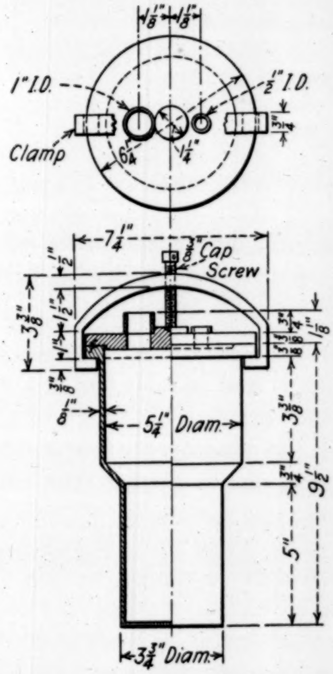


FIG. 2.—Iron Still for Use with Badly Foaming Emulsions.

If any evidence is noted of the emulsion beginning to foam over in the delivery tube, remove the 2-in. burner quickly and raise a pan of water so as to immerse the still bottom to a depth of about 2 in. for a moment which will check the foaming. Upon resumption of heating watch delivery tube carefully and repeat treatment if necessary.

When the residue has reached and remained at 500 F. (260 C.) for 15 min., proceed as described in Section 6 for the regular still. While the distillation should be completed in not less than 1 hr. nor more than $1\frac{1}{4}$ hr. from the first application of heat to the still, the maximum stated is not mandatory as a longer time may be required in some cases to avoid foaming of the emulsion into the condenser.

If the residue in the still prior to pouring the ductility and penetration specimens appears granular or heterogeneous in any way, stir with a spatula until the material runs from the spatula in strings instead of drops, and then pour. Should the residue then appear granular and heterogeneous, the test shall be rejected and the distillation repeated as previously described with the exception that the still temperature at 500 F. (260 C.) shall be maintained for a longer time than 15 min. until the desired condition of the residue is obtained.

DETERMINATION OF WATER

Scope

7. This method of test determines water existing in a sample of bituminous emulsion by distilling the sample with a volatile solvent.

Apparatus

8. (*a*) The apparatus shall consist of a metal still or glass flask, heated by suitable means and provided with a reflux condenser discharging into a trap connected to the still or flask. The trap serves to collect and measure the condensed water and to return the solvent to the still. The type of distilling apparatus used is not an essential feature of this method.

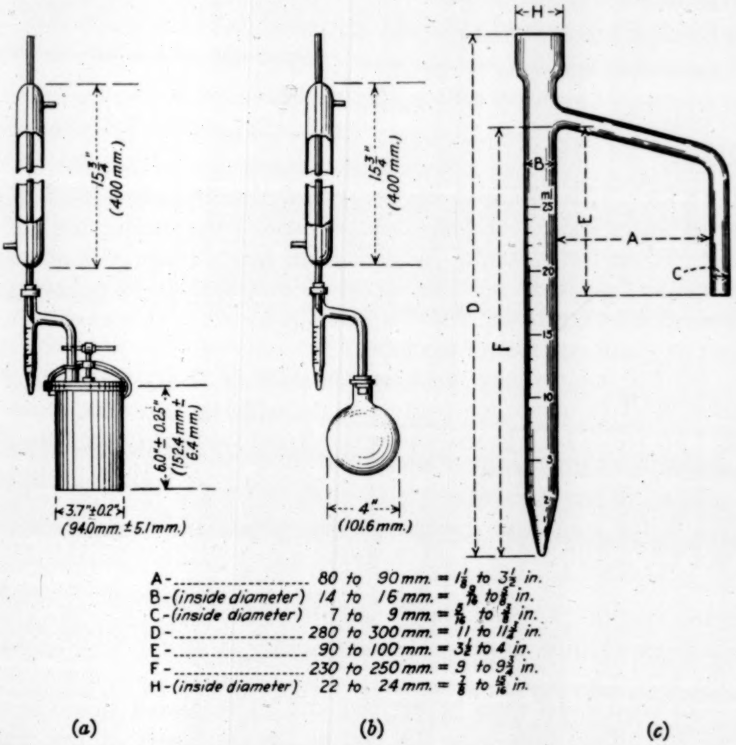
(*b*) *Metal Still.*—The metal still, Fig. 3 (*a*), shall be a vertical cylindrical vessel, preferably of copper, having a faced flange at the top to which the head is tightly attached by means of a clamp. The head shall be of metal, preferably of brass or copper, and be provided with a tubulation 1 in. in inside diameter.

(*c*) *Glass Still.*—The glass flask, Fig. 3 (*b*), shall be of the short neck, round-bottom type, made of well-annealed glass, having an approximate capacity of 500 ml.

(*d*) *Heat Source.*—The burner used with the metal still shall be a ring gas burner 100 mm. (4 in.) in inside diameter. With the glass flask, an ordinary gas burner or electric heater may be used as the source of heat.

(*e*) *Condenser.*—The condenser shall be of the water-cooled, reflux, glass-tube type, having a condenser jacket not less than 400 mm. ($15\frac{3}{4}$ in.) in length with an inner tube 9.5 to 12.7 mm. ($\frac{3}{8}$ to $\frac{1}{2}$ in.) in outside diameter. The end of the condenser to be inserted in the trap shall be ground off at an angle of 30 deg. from the vertical axis of the condenser.

(*f*) *Trap.*—The trap shall be made of well-annealed glass constructed in accordance with Fig. 3 (*c*) and shall be graduated from 0 to 25 ml. The tube shall be graduated from 0 to 2 ml. in 0.1 ml., from 2 to 5 ml. in 0.2 ml., and from 5 to 25 ml. in 0.5 ml. The outside diameters should be preferably 2.5 to 3.5 mm. ($\frac{3}{32}$ to $\frac{1}{8}$ in.) greater than the inside diameters specified.


$15\frac{3}{4}$" (400 mm.)
$15\frac{3}{4}$" (400 mm.)
6.0" ± 0.25" (152.4 mm ± 6.4 mm.)
3.7" ± 0.2" (94.0 mm. ± 5.1 mm.)
4" (101.6 mm.)
H
B
ml 25
20
15
10
5
2
1
A
C
D
E
F
(a)
(b)
(c)

A - 80 to 90 mm. = $1\frac{1}{8}$ to $3\frac{1}{2}$ in.
B - (inside diameter) 14 to 16 mm. = $\frac{9}{16}$ to $\frac{5}{8}$ in.
C - (inside diameter) 7 to 9 mm. = $\frac{5}{16}$ to $\frac{3}{8}$ in.
D - 280 to 300 mm. = 11 to $11\frac{3}{4}$ in.
E - 90 to 100 mm. = $3\frac{1}{2}$ to 4 in.
F - 230 to 250 mm. = 9 to $9\frac{3}{4}$ in.
H - (inside diameter) 22 to 24 mm. = $\frac{7}{8}$ to $\frac{15}{16}$ in.

FIG. 3.—Apparatus for Determining Water.

Solvent

9. The solvent used when testing bituminous emulsions shall be a coal-tar naphtha or a light oil and shall conform to the following distillation requirements, determined in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine,

and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials:[1]

98 per cent shall distill between 248 F. (120 C.) and 482 F. (250 C.).

Sample

10. The sample shall be thoroughly representative of the material to be tested and the portion of the sample used for the test shall be thoroughly representative of the sample itself. Deviation from this requirement shall not be permitted.

NOTE.—The difficulties in obtaining proper representative samples for this determination are unusually great so that the importance of sampling cannot be too strongly emphasized.

Procedure

11. (*a*) When the material to be tested contains less than 25 per cent of water, exactly a 100-g. sample shall be placed in the still or flask. When the material contains more than 25 per cent of water, the sample shall be 50 g. The sample to be tested shall be thoroughly mixed with an equal volume of solvent by swirling, proper care being taken to avoid any loss of material.

(*b*) The connections between the still or flask, trap and condenser shall be made by means of tight-fitting corks as shown in Fig. 3 (*a*) and (*b*). The end of the condenser inserted in the trap shall be adjusted to that position which will allow the end to be submerged to a depth of not more than 1 mm. (0.04 in.) below the surface of the liquid in the trap after distillation conditions have been established. When the metal still is used, a heavy paper gasket moistened with the solvent shall be inserted between the lid and flange before attaching the clamp. A loose cotton plug shall be inserted in the top of the condenser tube to prevent condensation of atmospheric moisture in the condenser tube.

(*c*) Heat shall then be applied and so regulated that the condensed distillate falls from the end of the condenser at the rate of from 2 to 5 drops per sec. The ring burner used with the metal still shall be placed about 3 in. above the bottom of the still at the beginning of the distillation and gradually lowered as the distillation proceeds.

(*d*) The distillation shall be continued at the specified rate until no water is visible on any part of the apparatus except at the bottom of the trap. This operation usually requires less than 1 hr. A persistent ring of condensed water in the condenser tube shall be removed by increasing the rate of distillation for a few minutes.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 778.

Calculation and Reporting of Results

12. The volume of condensed water measured in the trap at room temperature multiplied by 100 and divided by the weight of sample used, shall be the percentage of water and shall be reported as "...... per cent water by weight, A.S.T.M. method."

Accuracy

13. The accuracy to be expected with this method is that duplicate determinations of water should not differ from each other by more than one division on the trap.

SETTLEMENT

Apparatus

14. The following apparatus will be required:

(*a*) *Cylinders.*—Two glass cylinders of 500-ml. capacity with pressed or molded glass base and cork or glass stoppers. The outside diameter shall be 5.0 cm. ±0.5 cm. and the cylinders shall be graduated at each 5-ml. interval to the 500-ml. mark.

(*b*) *Glass Pipette.*—A syphon, glass tube pipette, 60-ml. capacity, form optional.

Procedure

15. (*a*) A 500-ml. sample, representative of the emulsion, shall be placed in each of two glass cylinders. The cylinder shall be stoppered air-tight and stood aside unmolested, at laboratory air temperature for 5 days. After standing for this 5-day period, approximately the first 55 ml. of emulsion shall be removed by means of the pipette or syphon from the top of each cylinder without disturbing the balance of their contents. Exactly 50 g. of each of the two samples, after each has been thoroughly mixed separately, shall be weighed into separate 600-ml. low-form glass beakers and the asphaltic residue determined by evaporation of 325 F. (163 C.) for 3 hr. in the apparatus described in the Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (A.S.T.M. Designation: D 6) of the American Society for Testing Materials.[1]

(*b*) After removal of the first sample, approximately the next 390 ml. shall be syphoned off from each of the cylinders. The residue remaining in the cylinders shall be mixed thoroughly and exactly 50 g. shall be weighed out from each of them and the amount of asphaltic residue (all sediment, if any, included) shall be determined by evaporation as described in Paragraph (*a*) for the two top samples.

(*c*) The numerical difference between the average percentage of asphaltic residue from the two top samples and the average percentage found in the two bottom samples shall be recorded.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 962.

DEMULSIBILITY

Apparatus and Reagents

16. The following apparatus and reagents will be required:

(*a*) *Sieves.*—Three No. 14 sieves of the U. S. Standard Sieve Series, of iron wire cloth, unframed, approximately 5-in. square, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[1]

(*b*) *Beakers.*—Three glass beakers of 600-ml. capacity each.

(*c*) *Glass Rods.*—Three glass rods, rounded ends, approximately $\frac{5}{16}$ in. in diameter.

(*d*) *Burette.*—A 50-ml. glass burette graduated in 0.1 ml.

(*e*) *Calcium Chloride Solution (0.02 N).*

(*f*) *Calcium Chloride Solution (0.10 N).*

Procedure

17. (*a*) The percentage of residue shall be determined by distillation as described in Section 6.

(*b*) The weight of each assembly of beaker, rod and sieve shall be recorded.

(*c*) Exactly 100 g. of the emulsified asphalt shall be weighed into each of three 600-ml. tared beakers. Over a period of approximately 2 min., 35 ml. of 0.02 N $CaCl_2$ solution (if quick-setting emulsion is being tested) or 50 ml. of 0.10 N $CaCl_2$ solution (if mixing type emulsion is being tested) shall be added to each beaker from a burette. While adding the solution of $CaCl_2$, the contents of the beaker shall be stirred continuously and vigorously, kneading lumps against the sides of the beaker to insure thorough mixing of the reagent with the emulsion. This operation shall be performed after bringing the weighed sample of emulsion and the reagent to the standard temperature of 77 F. ± 1.0 F. (25 C. ± 0.5 C.).

(*d*) One of the wire sieves shall be fitted over a beaker or other suitable vessel and the mixture of emulsion and reagent poured through the sieve. The beaker, containing the sample and glass rod, shall be rinsed with distilled water. All lumps shall be kneaded and broken up and the washing of the beaker, rod and sieve shall be continued until there is no longer any appreciable color imparted to the wash water. After washing as directed, the beaker, rod and sieve used in each individual test shall be placed in a drying oven and dried at 325 F. (163 C.) to constant weight.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

Calculation

18. The total weight thus obtained less the total tare weight of the beaker, rod and sieve shall be the weight of the residue by the demulsibility test. The ratio of the average weight in grams from three tests of each individual sample of emulsified asphalt, A, to the weight in grams of residue per 100 g. of emulsion, B, obtained in the test for residue by distillation described in Section 6 multiplied by 100, shall be recorded as the percentage of demulsibility of the sample tested:

$$\text{Percentage Demulsibility} = \frac{A}{B} \times 100$$

SIEVE TEST

Apparatus and Reagents

19. The following apparatus and reagents will be required:

(*a*) *Sieve.*—A No. 20 sieve, 3-in. in diameter with metal frame, of the U. S. Standard Sieve Series, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[1]

(*b*) *Pan.*—A tin box cover or shallow metal pan of appropriate size to fit over the bottom of the standard sieve.

(*c*) *Sodium Oleate Solution* (*2 per cent*).—Prepare a 2 per cent solution of pure sodium oleate in distilled water.

Procedure

20. The weight of the sieve and pan shall be recorded and the wire cloth of the No. 20 sieve shall then be wet with the sodium oleate solution (2 per cent). Exactly 1000 g. of the emulsified asphalt shall then be weighed and poured through the wire sieve, the container and the residue on the sieve being washed thoroughly with the sodium oleate solution until the washings run clear. The pan shall then be placed under the sieve and heated for 2 hr. in a drying oven whose interior temperature is 220 F. (105 C.), then cooled in a desiccator and weighed.

Calculation

21. The total weight of the sieve, pan, and residue in grams less the combined tare weight of the sieve and pan, is the weight of the residue by the sieve test. The percentage of residue in the emulsion shall be calculated on the basis of this weight.

MISCIBILITY WITH WATER

NOTE.—This test is not applicable to the so-called quick-setting type of emulsions.

Procedure

22. To about 50 ml. of the emulsion shall be gradually added about 150 ml. of distilled water, stirring the mixture while adding the water. The temperature is not important but should be between 21 and 25 C. (70 and 77 F.). The mixture shall be allowed to stand for 2 hr. and then examined for any appreciable coagulation of the asphalt content of the emulsion.

---

[1] **1933 Book of A.S.T.M. Standards, Part II, p. 1244.**

COATING TEST

NOTE.—This test is applicable only for emulsions containing a base of asphalt of semisolid consistency. It is not applicable to the so-called quick-setting type of emulsions.

Apparatus and Reagents

23. The following apparatus and reagents will be required:

(*a*) *Sieves.*—The No. 10 sieve, brass frame, of the U. S. Standard Sieve Series, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[1]

(*b*) *Screens.*—A standard ¾-in. screen and ¼-in. screen conforming to the requirements of the Standard Specifications for Round-Hole Screens for Testing Purposes (A.S.T.M. Designation: E 17) of the American Society for Testing Materials.[2]

(*c*) *Spatula.*—A steel spatula or its equivalent, blade approximately 8 in. in length.

(*d*) *Dish.*—A round-bottom, iron dish or a kitchen saucepan, approximately 1-qt. capacity.

(*e*) A supply of reference stone (hard limestone, trap rock, or other type) which has been washed with water and dried before using. The grading of this stone shall be such that it will all pass through a standard ¾-in. screen and not more than 5 per cent will pass through a ¼-in. screen.

NOTE.—Each laboratory shall select its own reference stone supply, the source of which is not apt to change. This is to obviate rapid changes in the character of reference stone used in any one laboratory.

Procedure

24. (*a*) Exactly 465 g. of the washed and dried graded stone, shall be weighed and placed in the metal pan.

(*b*) A 35-g. sample of the emulsion shall then be added to the stone in the pan and mixed vigorously with the spatula for 3 min.

(*c*) Record whether or not there is appreciable separation of the asphaltic base from the water of the emulsion and whether or not the stone is uniformly and thoroughly coated with the emulsion.

FREEZING TEST

Procedure

25. (*a*) Approximately 400 g. of the emulsion shall be placed in a clean metal container, such as a 1-pt. press-top tin.

(*b*) The emulsion in the closed container shall be exposed to a temperature of 0 F. (−17.7 C.) for twelve consecutive hours.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

[2] *Ibid.*, p. 1242.

(*c*) At the expiration of the freezing period, the emulsion shall be permitted to thaw by exposure of the container to the temperature of the laboratory.

(*d*) After the first operation of freezing and thawing, the procedure shall be repeated twice, so that the emulsion will have been subjected to three cycles of freezing and thawing.

(*e*) After the third cycle, the emulsion may be homogeneous or may have separated into distinct layers which cannot be rendered homogeneous by stirring at laboratory temperature.

(*f*) The result of this test shall be reported as either "Homogeneous" or "Broken."

PENETRATION OF RESIDUE

26. The penetration shall be determined upon a representative portion of the residue in accordance with the Standard Method of Test for Penetration of Bituminous Materials (A.S.T.M. Designation: D 5) of the American Society for Testing Materials.[1]

SOLUBILITY OF RESIDUE

27. The solubility in carbon disulfide shall be determined upon a representative portion of the residue in accordance with the Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4) of the American Society for Testing Materials.[2]

DUCTILITY OF RESIDUE

28. The ductility shall be determined upon a representative portion of the residue in accordance with the Tentative Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113 - 32 T) of the American Society for Testing Materials.[3]

SPECIFIC GRAVITY OF RESIDUE

29. The specific gravity shall be determined upon a representative portion of the residue in accordance with the Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (A.S.T.M. Designation: D 70) of the American Society for Testing Materials.[4]

ASH IN RESIDUE

30. The ash shall be determined upon a representative portion of the residue in accordance with the Rapid Routine Method of Ash Determination, as described in the Standard Methods of Analysis of Grease (A.S.T.M. Designation: D 128) of the American Society for Testing Materials.[5]

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 971.

[2] *Ibid.*, p. 945

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 781 (1932); also 1934 Book of A.S.T.M. Tentative Standards, p. 725.

[4] 1933 Book of A.S.T.M. Standards, Part II, p. 1002.

[5] *Ibid.*, p. 827.

TENTATIVE METHOD OF TEST
FOR
SEPARATION OF LIQUID ASPHALTIC PRODUCTS[1]

A.S.T.M. Designation: D 402 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1934.[2]

Scope

1. This method of test is intended for the separation of the volatile and non-volatile portions of cut-back asphaltic products.

APPARATUS

Apparatus

2. The apparatus shall consist of a flask, condenser, adapter, shield, receivers, and thermometer as specified in Sections 3 to 8.

Flask

3. The distillation flask, Fig. 1, shall be a side neck distilling flask, having the following dimensions:

Diameter of bulb, outside	86 mm. ± 1.5 mm.
Diameter of neck, inside	22 mm. ± 1.0 mm.
Diameter of tubulature, inside	10 mm. ± 0.5 mm.
Height of flask, outside	131 mm. ± 1.5 mm.
Vertical distance bottom of bulb, outside, to horizontal tangent at tubulature inside	93 mm. ± 1.5 mm.
Length of tubulature	220 mm. ± 5.0 mm.
Angle of tubulature	73 deg. ± 2 deg.
Thickness of tubulature wall	1.0 to 1.5 mm.

Condenser

4. The condenser may consist of a suitable condenser tube of the following dimensions provided with a 250-mm. standard glass jacket having an over-all length of approximately 270 mm. (see Fig. 3), or a glass jacketed condenser of the Liebig type may be used:

Outside diameter of small end	12.5 mm. ± 1.5 mm.
Outside diameter of large end	28.5 mm. ± 3.0 mm.
Length	360.0 mm. ± 4.0 mm.
Length of tapered part	100.0 mm. ± 5.0 mm.

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-4 on Road and Paving Materials.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

Adapter

5. The adapter shall be of the curved design of heavy wall (1 mm.) and reinforced top glass, with an angle of approximately 105 deg., and with a diameter at the large end of approximately 18 mm. The outlet end shall be ground to an angle of 45 deg. with the inside vertical.

Shield

6. A galvanized iron shield, lined with $\frac{1}{8}$-in. asbestos, fitted with transparent covered windows, of the form and dimensions shown in Fig. 2 shall be used to protect the flask from air currents and to prevent radiation. The cover (top) may be of transite board made in two parts, or it may be of galvanized iron lined with $\frac{1}{8}$-in. asbestos.

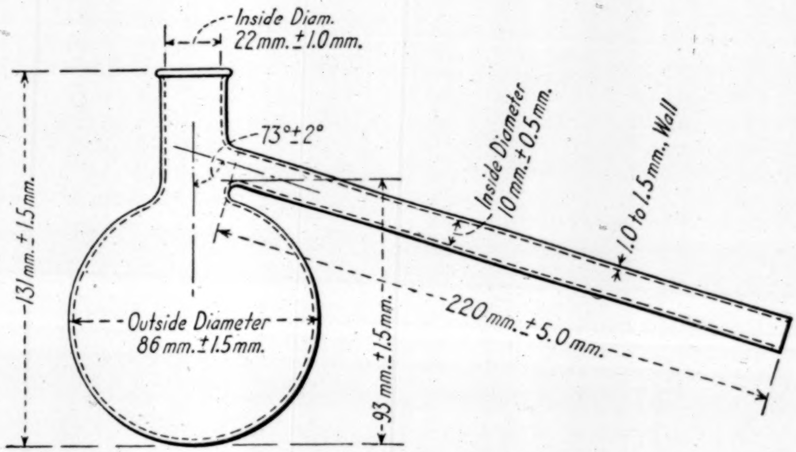


Fig. 1.—Distillation Flask.

Receivers

7. The receivers shall be graduated cylinders, of uniform diameter, with a pressed or molded base and a lipped top. The over-all height shall be not less than 24.8 cm. ($9\frac{3}{4}$ in.) nor more than 26.0 cm. ($10\frac{1}{4}$ in.). The cylinder shall be graduated in single milliliters to contain 100 ml., and the graduated portion shall be not less than 17.78 cm. (7 in.) nor more than 20.32 cm. (8 in.) in length. Each fifth graduation shall be distinguished by a longer line, and the graduations shall be numbered from the bottom up at intervals of 10 ml. The graduations shall not be in error by more than 1 ml. at any point on the scale.

Thermometer

8. The thermometer shall conform to the following requirements. These specifications cover a total-immersion thermometer graduated in either Centigrade or Fahrenheit degrees as specified, the range being from 0 to 400 C. or 30 to 760 F., respectively:

TYPE: Etched stem, glass.
LIQUID: Mercury.
RANGE AND SUBDIVISION: 0 to 400 C. in 1 C. or 30 to 760 F. in 2 F.

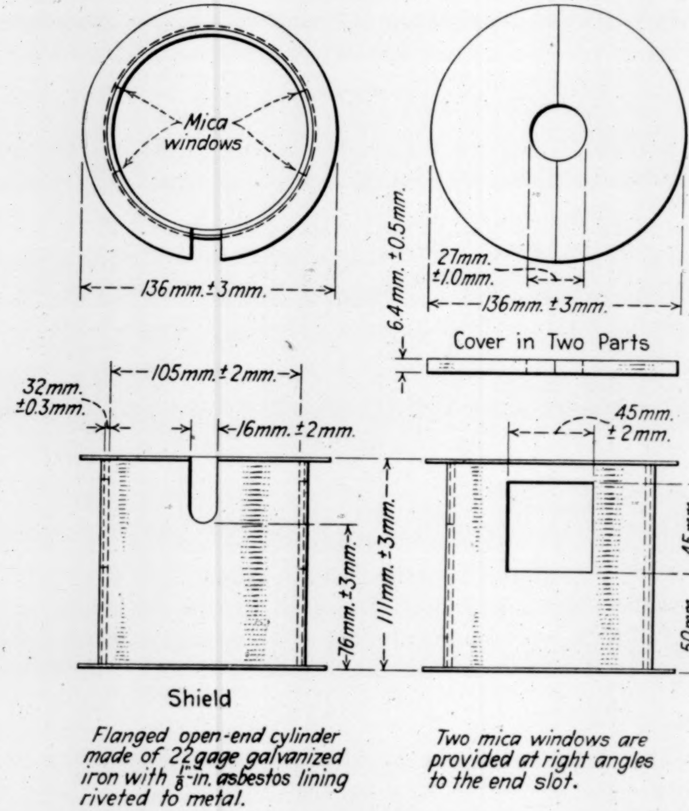

Mica windows
136mm.±3mm.
27mm. ±1.0mm.
136mm. ±3mm.
6.4mm. ±0.5mm.
Cover in Two Parts
105mm.±2mm.
32mm. ±0.3mm.
16mm. ±2mm.
45mm. ±2mm.
76mm. ±3mm.
111mm. ±3mm.
45mm. ±2mm.
50mm. ±2mm.
Shield
Flanged open-end cylinder made of 22 gage galvanized iron with ⅛-in. asbestos lining riveted to metal.
Two mica windows are provided at right angles to the end slot.

FIG. 2.—Shield.

TOTAL LENGTH: 378 to 384 mm. (14.88 to 15.12 in.).
STEM: Plain front, enamel back, suitable thermometer tubing. Diameter 6.0 to 7.0 mm. (0.24 to 0.28 in.).
BULB: Corning normal or equally suitable thermometric glass.
  Length, 10 to 15 mm. (0.39 to 0.59 in.).
  Diameter, 5.0 to 6.0 mm. (0.20 to 0.24 in.).
DISTANCE TO 0 C. OR 32 F. LINE FROM BOTTOM OF BULB: 25 to 35 mm. (0.98 to 1.38 in.).

DISTANCE TO 400 C. OR 752 F. LINE FROM TOP OF THERMOMETER: 30 to 45 mm. (1.18 to 1.77 in.).

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass ring.

GRADUATION: All lines, figures, and letters clear cut and distinct. The first and each succeeding 5 C. or 10 F. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 10 C. or 20 F.

IMMERSION: Total.

SPECIAL MARKING: "A.S.T.M. High Distillation," a serial number and the manufacturer's name or trade mark shall be etched on the stem.

SCALE ERROR: The error at any point of the scale up to 370 C. or 700 F. when the thermometer is standardized as provided below shall not exceed 1 C. or 2 F.

STANDARDIZATION: The thermometer shall be standardized immersed in the testing bath to the top of the mercury column, at the ice point and at temperature intervals of approximately 50 C. or 100 F. up to 370 C. or 700 F.

TEST FOR PERMANENCY OF RANGE: After being subjected to a temperature between 360 and 370 C. or 680 and 700 F. for 24 hr., the accuracy shall be within the limit specified. The test shall be made under the immersion conditions specified for this thermometer.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. High Distillation, 0 to 400 C." or "A.S.T.M. High Distillation, 30 to 760 F." according to the type of thermometer.

NOTE 1.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

NOTE 2.—Under certain test conditions the bulb of the thermometer may be 50 F. (28 C.) above the temperature indicated by the thermometer, and at an indicated temperature of 700 F. (371 C.) the temperature of the bulb is approaching a critical range in the glass. It is, therefore, not desirable to use this thermometer under such conditions at indicated temperatures above 700 F. (371 C.) without checking the ice point.

PREPARATION OF SAMPLE

Sampling

9. The sample, as received, shall be thoroughly stirred and agitated, warming, if necessary, to insure a complete mixture before the portion for analysis is removed.

Dehydration

10. The material may be tested for distillation without dehydration if water is present not to exceed 2.0 per cent. If water is present in excess of 2.0 per cent, the bituminous material shall be dehydrated before distillation in accordance with the Standard Method of Test for Water in Creosote Oil (A.S.T.M. Designation: D 370) of the American Society for Testing Materials.[1]

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 495.

PROCEDURE

Assembling Apparatus

11. (*a*) The flask shall be supported on a tripod or ring over two sheets of 20-mesh gauze, 150-mm. square as shown in Fig. 3. It shall be connected to the condenser tube by a tight cork joint. The thermometer shall be inserted through a cork in the neck with the bottom of the bulb $\frac{1}{4}$ in. from the bottom of the flask.

(*b*) The axis of the flask through the neck shall be vertical.

(*c*) The distance from the neck of the flask to the outlet end of the condenser tube shall be not more than 600 nor less than 500 mm. The burner should be protected from drafts by a suitable shield or chimney (see Fig. 3).

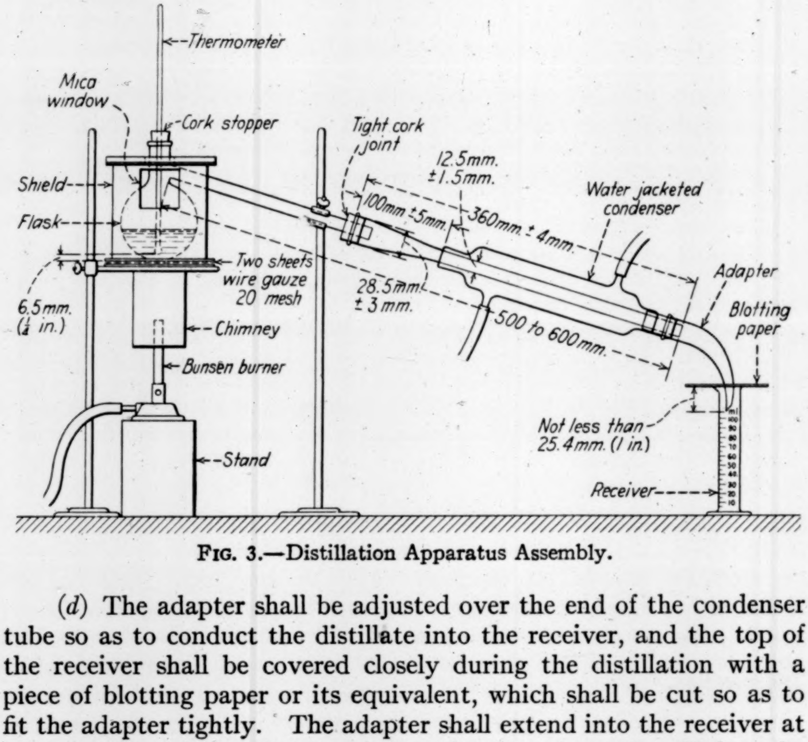

Thermometer
Mica window
Cork stopper
Shield
Flask
6.5 mm. ($\frac{1}{4}$ in.)
Two sheets wire gauze 20 mesh
Chimney
Bunsen burner
Stand
Tight cork joint
12.5 mm. ± 1.5 mm.
100 mm ± 5 mm.
360 mm. ± 4 mm.
28.5 mm. ± 3 mm.
500 to 600 mm.
Water jacketed condenser
Adapter
Blotting paper
Not less than 25.4 mm. (1 in.)
Receiver
ml

FIG. 3.—Distillation Apparatus Assembly.

(*d*) The adapter shall be adjusted over the end of the condenser tube so as to conduct the distillate into the receiver, and the top of the receiver shall be covered closely during the distillation with a piece of blotting paper or its equivalent, which shall be cut so as to fit the adapter tightly. The adapter shall extend into the receiver at least 2.54 cm. (1 in.) but not below the 100-ml. mark. Unless the laboratory air temperature is between 12.8 and 18.3 C. (55 and 65 F.) the receiver shall be immersed up to the 100-ml. mark in a transparent bath maintained between these temperatures.

(*e*) The condenser tube shall be clean and dry.

Distillation

12. (*a*) Two hundred milliliters (calculated from the specific gravity of the material at 15.5 C. (60 F.)) of the sample shall be weighed into the flask, the apparatus assembled and heat applied so that the first drop comes over in from 5 to 15 min. The distillation shall be conducted at the rate of between 50 and 70 drops per minute. Should the sample foam the distillation rate will have to be reduced, but the normal rate shall be resumed as soon as possible. If excess foaming persists the distillation may be more easily controlled by applying the flame near the edge of the bulb instead of at the center of same. The distillate shall be collected in the specified receivers, and the volume of distillate at all specified temperatures recorded. The volume of any separated water shall also be recorded. When the maximum specified temperature of the test is indicated by the thermometer, the flame shall be removed and the residue poured *immediately* into a 6-oz. tin box placed on its cover to prevent two rapid cooling at the bottom. Any oil which may remain in the condenser tube shall be drained into the last receiver.

(*b*) As soon as no further vaporization is apparent, the residue shall be stirred to insure homogeneity, and then poured into the necessary apparatus for the required tests.

(*c*) During the progress of the distillation the thermometer shall remain in its original position. No correction shall be made for the emergent stem of the thermometer. Temperatures to be observed in the distillation test shall be corrected for the effect of the altitude of the laboratory in which the test is made in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials.[1]

(*d*) The results of the distillation test shall be reported in percentage by volume of water-free material. The following fractions are usually reported:

Up to 225 C. (437 F.)
Up to 315 C. (600 F.)
Up to 360 C. (680 F.)

Additional fractions may be specified such as 160 C. (320 F.), 175 C. (347 F.) and 190 C. (374 F.).

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 778.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT SHINGLES SURFACED WITH COARSE MINERAL GRANULES[1]

A.S.T.M. Designation: D 225 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1925; ADOPTED IN AMENDED FORM, 1927; REVISED, 1929; REISSUED AS TENTATIVE, 1933; REVISED, 1934.

Scope

1. These specifications cover asphalt roofing in shingle form surfaced with colored mineral granules, composed of roofing felt saturated and coated on both sides with asphalt and surfaced on the weather side with granulated slate or equivalent mineral material (of solid or mixed colors as may be mutually agreed upon between the purchaser and seller), and on the reverse side with powdered talc or mica. Such roofing is intended for use as a roof covering for buildings.

Manufacture

2. In the process of manufacture, a single thickness of dry roofing felt shall be impregnated with a hot asphaltic saturant, then coated on both sides with a hot asphaltic coating compounded with a fine mineral filler, and finally surfaced on one side with mineral granules embedded in the hot asphaltic coating. The reverse side shall be covered with powdered talc or mica to prevent the roofing from sticking together in the package.

Character of Felt

3. The felt shall be composed of a continuous sheet of "felted" vegetable and animal fibers. Its surface shall be uniformly smooth and free from lumps of unbeaten stock and particles of hard foreign substances.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

These specifications are in effect a revision of the former Standard Specifications for Asphalt **Roll-Roofing and Asphalt Shingles Surfaced with** Mineral Granules (A.S.T.M. Designation: D 225 - **29), which standard was accordingly discontinued in 1933.**

Character of Saturant and Coatings

4. The saturant and coatings shall be composed principally of asphaltic materials.

Physical Properties

5. The fabricated product shall conform to the following requirements:

(*a*) *Shape.*—The form and size of the shingles shall be as agreed upon between the purchaser and seller.

(*b*) *Area.*—Sufficient material per "square" shall be furnished to adequately waterproof 100 sq. ft. of roof surface.

	GRADES			
	HEAVY WEIGHT		REGULAR WEIGHT	
	MAX., LB.	MIN., LB.	MAX., LB.	MIN., LB.
(*c*) Weight, net avg. per 108 sq. ft.	....	102.0	....	86.0
(*d*) Weight of dry felt per 108 sq. ft.	....	15.7	....	10.8
(*e*) Weight of saturant per 108 sq. ft.[a]	....	27.5	....	18.9
(*f*) Weight of front coating (soluble in CS_2) per 108 sq. ft.	20.0	12.0	20.0	12.0
(*g*) Weight of back coating (soluble in CS_2) per 108 sq. ft.	5.0	2.0	5.0	2.0
(*h*) Weight of mineral matter per 108 sq. ft. passing No. 6 and retained on No. 100 sieve	40.0	25.0	40.0	25.0
(*i*) Weight of mineral matter per 108 sq. ft. passing No. 100 sieve	10.0	4.0	10.0	4.0
(*j*) Weight of complete roofing per 108 sq. ft.	....	97.0	....	83.0
(*k*) Behavior on heating to 176 F. (80 C.) for 2 hr.	not more than 1.5 per cent volatile matter loss. The granular surfacing shall not slide more than $\frac{1}{16}$ in. when suspended vertically.			

---

[a] The weight of saturant per 108 sq. ft. shall be not less than 1.75 times the weight of the dry felt.

Surface Finish

6. (*a*) The weather surface shall be uniform in finish and texture. The mineral granules shall be uniformly distributed over the entire surface and so firmly embedded in the asphalt coating that when rubbed vigorously with the hand, sufficient will remain to completely cover the coating.

(*b*) The reverse side shall have a substantial coating of asphalt applied uniformly to the edges and be surfaced with powdered talc or mica.

Saturation

7. The felt shall be completely and uniformly saturated and shall show no unsaturated spots at any point when the roofing is cut or split open.

Freedom from Defects

8. The finished shingles shall be free from visible external defects such as holes, ragged or untrue edges, rents, cracks, indentations or lumps of coating. The shingles shall not stick together in the packages so as to cause damage upon being unpacked at atmospheric temperatures above 50 F. (10 C).

Packing

9. (*a*) The shingles shall be put up in bundles weighing not more than 135 lb., gross. They shall be packed in cardboard cartons or between wood or cardboard ends and tied with wire or metal bands so as to make a substantial package, as may be agreed upon by the purchaser and seller.

(*b*) Each package shall be plainly marked with the manufacturer's name and brand and shall contain printed directions for laying.

Sampling and Testing

10. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 228 – 33 T) of the American Society for Testing Materials.[1]

Inspection

11. Inspection of material shall be made as mutually agreed upon by the purchaser and seller as part of the purchase contract.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 799 (1933); also 1934 Book of A.S.T.M. Tentative Standards, p. 772.

TENTATIVE SPECIFICATIONS

FOR

ASPHALT ROOFING SURFACED WITH POWDERED TALC OR MICA[1]

A.S.T.M. Designation: D 224 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1925; ADOPTED IN AMENDED FORM, 1927; REISSUED AS TENTATIVE, 1933; REVISED, 1934.

Scope

1. These specifications cover asphalt roofing in sheet form surfaced with finely powdered mineral matter, either 36 or 32 in. in width, composed of roofing felt saturated and coated on both sides with asphalt. Such roofing is intended for use as a roof covering for buildings.

Manufacture

2. In the process of manufacture, a single thickness of dry roofing felt shall be impregnated with a hot asphaltic saturant then coated on both sides with a hot asphaltic coating compounded with a finely powdered mineral filler, and finally surfaced on both sides with powdered talc or mica to prevent the roofing from sticking together in the package.

Character of Felt

3. The felt shall be composed of a continuous sheet of "felted" vegetable and animal fibers. Its surface shall be uniformly smooth and free from lumps of unbeaten stock and particles of hard foreign substances.

Character of Saturant and Coatings

4. The saturant and coatings shall be composed principally of asphaltic materials.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

These specifications are in effect a revision of the former Standard Specifications for Asphalt Roll-Roofing Surfaced with Powdered Talc (A.S.T.M. Designation: D 224 - 27), which standard was accordingly discontinued in 1933.

Physical Properties

5. The fabricated product shall conform to the following requirements:

(*a*) *Width.*—The roofing shall be put up in rolls and shall be either 36 or 32 in. in width, as may be specified, within a permissible variation of ± ¼ in.

(*b*) *Area.*—The average area of the rolls examined shall contain not less than 108 or 216 sq. ft., as specified, which shall be sufficient to cover 100 or 200 sq. ft., respectively, of roof surface.

	GRADES			
	65 LB.		55 LB.	
	MAX., LB.	MIN., LB.	MAX., LB.	MIN., LB.
(*c*) Weight per roll, net avg. per 108 sq. ft.	....	62.0	....	52.0
(*d*) Weight of dry felt per 108 sq. ft.	....	13.5	....	10.8
(*e*) Weight of saturant (soluble in CS_2) per 108 sq. ft.[a]	....	21.6	....	17.5
(*f*) Weight of coating (soluble in CS_2) per 108 sq. ft.	20.0	15.0	20.0	15.0
(*g*) Weight of mineral matter per 108 sq. ft. passing a No. 100 sieve	8.0	4.0	8.0	4.0
(*h*) Weight of complete roofing per 108 sq. ft.	....	60.0	....	50.0
(*i*) Pliability at 77 F. (25 C.)	at least 8 strips out of 10 shall not crack when bent 90 deg. at a uniform speed over a rounded corner of ½-in. radius.			
(*j*) Behavior on heating to 176 F. (80 C.) for 2 hr	not more than 1.5 per cent volatile matter loss. There shall be no flowing, sagging, blistering or absorption of the asphalt coatings.			

---

[a] The weight of saturant per 108 sq. ft. shall be not less than 1.6 times the weight of the dry felt.

Surface Finish

6. The surface shall be smooth or finely veined in appearance. Deeply ribbed surfaces shall be rejected.

Distribution of Coating and Surfacing

7. The coating and surfacing shall be applied uniformly and of approximately equal thickness on both sides and up to the edges of the sheet.

Freedom from Defects

8. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, rents, cracks, tears, protuberances and indentations.

Pliability and Stickiness

9. The finished product shall not crack or be so sticky as to cause tearing or material damage, upon being unrolled at atmospheric temperatures above 50 F. (10 C.).

Packing

10. (*a*) The roofing shall be put up in rolls of either 108 or 216 sq. ft. No roll shall contain more than two pieces nor shall there be more than 3 per cent of the rolls containing two pieces in any shipment. The rolls shall be tightly wound and securely wrapped in a substantial grade of paper completely encircling the roll, and pasted at the overlap in such a manner as to prevent shifting from position. The ends of the rolls shall be protected with cloth covers or by other suitable means. The nails and lap-cement shall be packed in the core of each roll or furnished separately if so specified by the purchaser.

(*b*) Each roll shall be plainly marked with the manufacturer's name and brand. Special packing shall be as agreed upon between the purchaser and seller.

Nails and Lap-Cement

11. (*a*) *Nails.*—The gage of the wire shall not be greater than "A. S. & W." No. 10 (0.135 in.) nor thinner than No. 12 (0.105 in.); the head shall not be less than $\frac{3}{8}$ in. in diameter, and not less than 0.025 in. in thickness; the shank shall be between $\frac{3}{4}$ and 1 in. in length, with its lower end pointed, and shall be either smooth or barbed, and if the latter, then the barbings shall not increase the diameter of the lower two-thirds more than 0.01 in. The nails shall be zinc coated with not less than $\frac{1}{2}$ oz. nor more than $1\frac{1}{4}$ oz. per sq. ft. of nail surface. Hot-galvanized, electrogalvanized, or sherardized coatings will be accepted. There shall be furnished per "square" not less than an average of 252 nails for 36-in. roofing and not less than an average of 275 nails for 32-in. roofing.

(*b*) *Lap-Cement.*—The cement shall be composed of bituminous materials dissolved in a volatile solvent, and shall be of such a nature as to firmly bind the laps without injurious effect upon the roofing. The cement shall have a minimum flash point of 71 F. (21.5 C.) when tested by the Tag Closed-Cup Tester. There shall be furnished for each "square" of 36-in. roofing not less than $\frac{3}{4}$ pt. of cement and for 32-in. roofing not less than 1 pt. of cement. The addition of 5 to 20 per cent by weight of short-fibered asbestos shall be permitted, in which case the quantity of cement shall be increased by $\frac{1}{4}$ pt. per "square."

(*c*) *Special Fixtures.*—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller.

Sampling and Testing

12. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the

Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc, or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 228 - 33 T) of the American Society for Testing Materials.[1]

Inspection

13. Inspection of material shall be made as mutually agreed upon by the purchaser and seller as part of the purchase contract.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 799 ('933); also 1934 Book of A.S.T.M. Tentative Standards, p. 772.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT ROOFING SURFACED WITH FINE MINERAL GRANULES[1]

A.S.T.M. Designation: D 248 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1926; ADOPTED, 1927; REISSUED AS TENTATIVE, 1933; REVISED, 1934.

Scope

1. These specifications cover asphalt roofing in sheet form surfaced on the weather side with fine mineral granules, either 36 or 32 in. in width, composed of roofing felt saturated and coated on both sides with asphalt. Such roofing is intended for use as a roof covering for buildings.

Manufacture

2. In the process of manufacture, a single thickness of dry roofing felt shall be impregnated with a hot asphaltic saturant then coated on both sides with a hot asphalt coating compounded with a fine mineral filler, and finally surfaced on one side with fine granules of talc or other mineral material, and of a color as may be mutually agreed upon between the purchaser and seller, embedded in the hot asphaltic coating. The reverse side shall be covered with powdered talc or mica to prevent the roofing from sticking together in the package.

Character of Felt

3. The felt shall be composed of a continuous sheet of "felted" vegetable and animal fibers. Its surface shall be uniformly smooth and free from lumps of unbeaten stock and particles of hard foreign substances.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

These specifications are in effect a revision of the former Standard Specifications for Asphalt Roll-Roofing Surfaced with Granular Talc (A.S.T.M. Designation: D 248 - 27), which standard was accordingly discontinued in 1933.

Character of Saturant and Coatings

4. The saturant and coatings shall be composed principally of asphaltic materials.

Physical Properties

5. The fabricated product shall conform to the following requirements:

(*a*) *Width.*—The roofing shall be put up in rolls and shall be either 36 or 32 in. in width, as may be specified, within a permissible variation of ±¼ in.

(*b*) *Area.*—The average area of the rolls examined shall contain not less than 108 or 216 sq. ft., as specified, which shall be sufficient to cover 100 or 200 sq. ft., respectively, of roof surface.

<table>
<tr><th rowspan="3"></th><th colspan="4">GRADES</th></tr>
<tr><th colspan="2">65 LB.</th><th colspan="2">55 LB.</th></tr>
<tr><th>MAX., LB.</th><th>MIN., LB.</th><th>MAX., LB.</th><th>MIN., LB.</th></tr>
<tr><td>(<i>c</i>) Weight per roll, net avg. per 108 sq. ft.</td><td>....</td><td>62.0</td><td>....</td><td>52.0</td></tr>
<tr><td>(<i>d</i>) Weight of dry felt per 108 sq. ft.</td><td>....</td><td>13.5</td><td>....</td><td>10.8</td></tr>
<tr><td>(<i>e</i>) Weight of saturant (soluble in CS_2) per 108 sq. ft.[a]</td><td>....</td><td>21.6</td><td>....</td><td>17.5</td></tr>
<tr><td>(<i>f</i>) Weight of coating (soluble in CS_2) per 108 sq. ft.</td><td>20.0</td><td>10.0</td><td>20.0</td><td>10.0</td></tr>
<tr><td>(<i>g</i>) Weight of mineral matter per 108 sq. ft.:</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Passing No. 14 and retained on No. 100 sieve</td><td>17.0</td><td>3.0</td><td>12.0</td><td>3.0</td></tr>
<tr><td>Passing No. 100 sieve</td><td>10.0</td><td>3.0</td><td>10.0</td><td>3.0</td></tr>
<tr><td>(<i>h</i>) Weight of complete roofing per 108 sq. ft.</td><td>....</td><td>60.0</td><td>....</td><td>50.0</td></tr>
<tr><td>(<i>i</i>) Pliability at 77 F. (25 C.)</td><td colspan="4">at least 8 strips out of 10 shall not crack when bent 90 deg. at a uniform speed over a rounded corner of ½-in. radius.</td></tr>
<tr><td>(<i>j</i>) Behavior on heating to 176 F. (80 C.) for 2 hr</td><td colspan="4">not more than 1.5 per cent volatile matter loss. There shall be no flowing, sagging, blistering, or absorption of the asphalt coatings.</td></tr>
</table>

---

[a] The weight of saturant per 108 sq. ft. shall be not less than 1.6 times the weight of the dry felt.

Surface Finish

6. The surface shall be smooth or finely veined in appearance. Deeply ribbed surfaces shall be rejected.

Distribution of Coating and Surfacing

7. The coating and surfacing shall be applied uniformly and of approximately equal thickness on both sides and up to the edges of the sheet.

Freedom from Defects

8. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, rents, cracks, tears, protuberances and indentations.

Pliability and Stickiness

9. The finished product shall not crack or be so sticky as to cause tearing or material damage, upon being unrolled at atmospheric temperatures above 50 F. (10 C.).

Packing

10. (*a*) The roofing shall be put up in rolls of either 108 or 216 sq. ft. No roll shall contain more than two pieces nor shall there be more than 3 per cent of the rolls containing two pieces in any shipment. The rolls shall be tightly wound and securely wrapped in a substantial grade of paper completely encircling the roll, and pasted at the overlap in such a manner as to prevent shifting from position. The ends of the rolls shall be protected with cloth covers or by other suitable means. The nails and lap-cement shall be packed in the core of each roll or furnished separately if so specified by the purchaser.

(*b*) Each roll shall be plainly marked with the manufacturer's name and brand. Special packing shall be as agreed upon between the purchaser and seller.

Nails and Lap-Cement

11. (*a*) *Nails.*—The gage of the wire shall not be greater than "A. S. & W." No. 10 (0.135 in.) nor thinner than No. 12 (0.105 in.); the head shall not be less than $\frac{3}{8}$ in. in diameter, and not less than 0.025 in. in thickness; the shank shall be between $\frac{3}{4}$ and 1 in. in length, with its lower end pointed, and shall be either smooth or barbed, and if the latter, then the barbings shall not increase the diameter of the lower two-thirds more than 0.01 in. The nails shall be zinc coated with not less than $\frac{1}{2}$ oz. nor more than $1\frac{1}{4}$ oz. per sq. ft. of nail surface. Hot-galvanized, electrogalvanized, or sherardized coatings will be accepted. There shall be furnished per "square" not less than an average of 252 nails for 36-in. roofing, and not less than an average of 275 nails for 32-in. roofing.

(*b*) *Lap-Cement.*—The cement shall be composed of bituminous materials dissolved in a volatile solvent, and shall be of such a nature as to firmly bind the laps without injurious effect upon the roofing. The cement shall have a minimum flash point of 71 F. (21.5 C.) when tested by the Tag Closed-Cup Tester. There shall be furnished for each "square" of 36-in. roofing not less than $\frac{3}{4}$ pt. of cement and for 32-in. roofing not less than 1 pt. of cement. The addition of 5 to 20 per cent by weight of short-fibered asbestos shall be permitted, in which case the quantity of cement shall be increased by $\frac{1}{4}$ pt. per "square."

(*c*) *Special Fixtures.*—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller.

Sampling and Testing

12. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc, or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 228 - 33 T) of the American Society for Testing Materials.[1]

Inspection

13. Inspection of material shall be made as mutually agreed upon by the purchaser and seller as part of the purchase contract.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p 799 (1933); also 1934 Book of A.S.T.M. Tentative Standards, p. 772.

TENTATIVE SPECIFICATIONS

FOR

ASPHALT ROOFING SURFACED WITH COARSE MINERAL GRANULES[1]

A.S.T.M. Designation: D 249 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1926; ADOPTED, 1927; REISSUED AS TENTATIVE, 1933; REVISED, 1934.

Scope

1. These specifications cover asphalt roofing in sheet form surfaced with colored mineral granules, either 36 or 32 in. in width, composed of roofing-felt saturated and coated on both sides with asphalt and surfaced on the weather side with granulated slate or equivalent mineral material (of solid or mixed colors as may be mutually agreed upon between the purchaser and seller), and on the reverse side with powdered talc or mica. Such roofing is intended for use as a roof covering for buildings.

Manufacture

2. In the process of manufacture, a single thickness of dry roofing felt shall be impregnated with a hot asphaltic saturant, then coated on both sides with a hot asphaltic coating compounded with a fine mineral filler, and finally surfaced on one side with mineral granules embedded in the hot asphaltic coating. The reverse side shall be covered with powdered talc or mica to prevent the roofing from sticking together in the package.

Character of Felt

3. The felt shall be composed of a continuous sheet of "felted" vegetable and animal fibers. Its surface shall be uniformly smooth and free from lumps of unbeaten stock and particles of hard foreign substances.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-8 on Bituminous Waterproofing and Roofing Materials.

These specifications are in effect a revision of the former Standard Specifications for Heavy Weight Asphalt Roll-Roofing and Heavy Weight Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 249 - 27), which standard was accordingly discontinued in 1933.

Character of Saturant and Coatings

4. The saturant and coatings shall be composed principally of asphaltic materials.

Physical Properties

5. The fabricated product shall conform to the following requirements:

(*a*) *Width.*—The roofing shall be put up in rolls and shall be either 36 or 32 in. in width, as may be specified, within a permissible variation of ± ¼ in.

(*b*) *Area.*—The average area of the rolls examined shall contain sufficient roofing to cover 100 sq. ft. of roof surface (108 sq. ft. with 2 in. or no bare lapping edge, or 111 sq. ft. with 3 in. lapping edge).

	GRADES			
	105 LB.		90 LB.	
	MAX., LB.	MIN., LB.	MAX., LB.	MIN., LB.
(*c*) Weight per roll, net avg... No bare edge..........	....	97.0	....	83.0
(*c*) Weight per roll, net avg... 2 or 3 in. bare edge.....	....	95.0	....	81.0
(*d*) Weight of dry felt per 108 sq. ft..........	....	15.7	....	10.8
(*e*) Weight of saturant (soluble in CS_2) per 108 sq. ft.[a]............................	....	25.1	....	17.3
(*f*) Weight of front coating (soluble in CS_2) per 108 sq. ft..........................	20.0	12.0	20.0	12.0
(*g*) Weight of back coating (soluble in CS_2) per 108 sq. ft..........................	5.0	2.0	5.0	2.0
(*h*) Weight of mineral matter per 108 sq. ft. passing No. 6 and retained on No. 100 sieve............................	40.0	25.0	40.0	25.0
(*i*) Weight of mineral matter per 108 sq. ft. passing No. 100 sieve................	10.0	4.0	10.0	4.0
(*j*) Weight of complete roofing per 108 sq. ft. (coarse granule surfaced portion).....	....	94.0	....	80.0
(*k*) Pliability at 77 F. (25 C.)................	at least 8 strips out of 10 shall not crack when bent 90 deg. at a uniform speed over a rounded corner of ¾-in. radius.			
(*l*) Behavior on heating to 176 F. (80 C.) for 2 hr............................	not more than 1.5 per cent volatile matter loss. The granular surfacing shall not slide more than 1/16 in. when suspended vertically.			

---

[a] The weight of saturant per 108 sq. ft. shall be not less than 1.6 times the weight of the dry felt.

Surface Finish

6. (*a*) The weather surface shall be uniform in finish and texture. The mineral granules shall be uniformly distributed over the entire surface (except as noted in Paragraph (*b*)) in a smooth layer and shall be so firmly embedded in the asphaltic coating that when rubbed vigorously with the hand, sufficient will remain to completely cover the coating.

(*b*) The coating and granules shall cover the entire weather side of the roofing, except that this side may be provided with a bare lapping edge, approximately 2 or 3 in. in width along one edge, where either the granules alone or both the granules and coating may be omitted.

(*c*) The reverse side of the sheet shall have the asphalt coating and powdered surfacing applied uniformly to the edges.

Distribution of Coating and Surfacing

7. The felt shall be completely and uniformly saturated, and shall show no unsaturated spots at any point when the roofing is cut or split open.

Packing

9. (*a*) The roofing shall be put up in rolls of either 108 sq. ft. when made with a 2-in. or no bare-lapping edge or 111 sq. ft. when made with a 3-in. bare-lapping edge. No roll shall contain more than two pieces nor shall there be more than 3 per cent of the rolls containing two pieces in any shipment. The rolls shall be tightly wound, and securely wrapped with a substantial grade of paper completely encircling the roll, and pasted at the overlap in such a manner as to prevent shifting from position. The ends of the rolls shall be protected with cloth covers or by other suitable means. The nails and lap-cement shall be packed in the core of each roll or furnished separately if so specified by the purchaser.

(*b*) Each roll shall be plainly marked with the manufacturer's name and brand. Special packing shall be as agreed upon between the purchaser and seller.

Nails and Lap-Cement

10. (*a*) *Nails.*—The gage of the wire shall not be greater than "A. S. & W." No. 10 (0.135 in.) nor thinner than No. 12 (0.105 in.); the head shall not be less than $\frac{3}{8}$ in. in diameter, and not less than 0.025 in. in thickness; the shank shall be between $\frac{3}{4}$ and 1 in. in length, with its lower end pointed, and shall be either smooth or barbed, and if the latter, then the barbings shall not increase the diameter of the lower two-thirds more than 0.01 in. The nails shall be zinc coated with not less than $\frac{1}{2}$ oz. nor more than $1\frac{1}{4}$ oz. per sq. ft. of nail surface. Hot-galvanized, electrogalvanized, or sherardized coatings will be accepted. There shall be furnished per "square" not less than an average of 252 nails for 36-in. roofing, and not less than an average of 275 nails for 32-in. roofing.

(*b*) *Lap-Cement.*—The cement shall be composed of bituminous materials dissolved in a volatile solvent, and shall be of such a nature as to firmly bind the laps without injurious effect upon the roofing. The cement shall have a minimum flash point of 71 F. (21.5 C.) when tested by the Tag Closed-Cup Tester. There shall be furnished for each "square" of 36-in. roofing not less than $\frac{3}{4}$ pt. of cement and for 32-in. roofing not less than 1 pt. of cement. The addition of 5 to 20 per cent by weight of short-fibered asbestos shall be permitted, in which case the quantity of cement shall be increased by $\frac{1}{4}$ pt. per "square."

(*c*) *Special Fixtures.*—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller.

Sampling and Testing

11. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc, or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules (A.S.T.M. Designation: D 228 – 33 T) of the American Society for Testing Materials.[1]

Inspection

12. Inspection of material shall be made as mutually agreed upon by the purchaser and seller as part of the purchase contract.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 799 (1933); also 1934 Book of A.S.T.M. Tentative Standards, p. 772.

TENTATIVE SPECIFICATIONS

FOR

BLACK BIAS-CUT VARNISHED CLOTH TAPE USED FOR ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 373 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1933; REVISED, 1934.

Scope

1. These specifications cover black seamless and sewed-seam bias-cut varnished cloth tapes 7 to 12 mils in thickness to be used for insulating bus bars, joints and terminals of electric wires and cables, and other electrical apparatus connections.

NOTE.—Orders for material under these specifications shall include the following information:

The desired nominal thickness, width and length (Sections 7, 8 and 9);
Whether seamless or sewed-seam tapes are desired (Sections 4 and 5);
Type of surface, greasy or tacky (Section 10);
Type of packing, dry or oil (Sections 18, 19 and 20);
Number of rolls in package (Sections 19 and 20); and
Marking on package (Section 21).

MANUFACTURE

Cloth and Varnish

2. The cloth and the number of coats of varnish applied shall be such as to produce a product which will meet the requirements of these specifications.

Defects

3. In general, the tape shall be free from wrinkles, excessive pebbling, blisters, and other imperfections.

Splices

4. Splices are those joints made by the manufacturer of the untreated cloth. In the case of seamless bias-cut tapes, splices shall not occur more than once in each roll, except that rolls having a length of 6 yd. or less shall contain no splices.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

Seams

5. Seams are those joints made during or subsequent to the varnish treatment of the cloth. In the case of sewed-seam bias-cut tapes, seams shall not occur more than once in each 45 in. of length.

METHODS OF TESTING

Methods of Testing

6. (*a*) Varnished cloth tape shall be sampled, conditioned and tested in accordance with the Tentative Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (A.S.T.M. Designation: D 295 – **34** T) of the American Society for Testing Materials.[1]

(*b*) All specimens taken from a single roll shall be numbered or marked so that failures can be identified with the roll.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Thickness

7. The nominal thickness shall be specified in the purchase order. The average thickness shall be determined from the ten measurements taken on a specimen before testing in accordance with Section 15, the five measurements on the specimen before testing in accordance with Section 16, and the other five measurements on the specimen before testing in accordance with Section 17. The average thickness shall not vary more than ± 12 per cent from the specified nominal thickness and no individual measurement shall vary by more than 20 per cent from the specified nominal thickness.

Width

8. The nominal width shall be specified in the purchase order. Individual measurements on all the samples selected under Section 6 shall not vary more than $\pm\frac{1}{32}$ in. from the specified nominal width for tapes 1 in. or less in width, nor more than $\pm\frac{1}{16}$ in. for tapes over 1 in. in width.

Length

9. The nominal length or yards per roll shall be specified in the purchase order. The measured lengths of individual rolls selected under Section 6 shall be not less than that specified.

PHYSICAL PROPERTIES AND TESTS

Surface

10. Tapes are roughly divisible into two classes: "greasy" and "tacky." Greasy tapes shall have the property of sliding freely, one layer upon another, when moved easily between two fingers.

---

[1] See p. 1074.

Flexibility

11. The varnish coating shall be flexible and shall not crack when the tape is doubled upon itself and creased between the thumb and index finger.

Tensile Breaking Strength

12. (*a*) The tensile breaking strength requirement varies with the nominal thickness of the tape. Let t represent the nominal thickness in mils; then, the average tensile breaking strength of the specimens should be not less than $35 + (t-7)$ lb. per inch of width. If the first specimen from a roll does not conform to this requirement, tests of two additional specimens from the same roll shall be made. Then the average of the three tests shall conform to the above requirements. The tensile breaking strength of any of the tests made shall be not less than $29 + (t-7)$ lb. per inch of width.

(*b*) The tensile breaking strength of the "jointed selvages," in the case of seamless bias-cut tapes, shall not be less than 80 per cent of the values specified in Paragraph (*a*).

(*c*) The tensile breaking strength of the "seams," in the case of sewed-seam bias-cut tapes, shall not be less than 60 per cent of the values specified in Paragraph (*a*).

Elongation

13. (*a*) For tapes of nominal width not less than 0.5 in., the elongation of one specimen from each of the selected rolls shall be measured at a temperature T between 20 and 30 C. and shall be not less than that specified in the following table:

NOMINAL THICKNESS	LOAD, LB. PER INCH OF TAPE WIDTH	ELONGATION, PER CENT
7 mils	5	$1.7 + (T-20) \times 0.1$
Over 7 mils	6	$1.7 + (T-20) \times 0.1$

(*b*) The specimens tested for elongation shall be used for electrical tests as described in Section 16.

Resistance to Oil

14. (*a*) One specimen from each of the selected rolls shall be subjected to test for resistance to oil described in the test methods referred to in Section 6. The oil used shall be an insulating oil having a flash point of not less than 135 C. (275 F.), as determined by the Cleveland open cup in accordance with the Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92) of the American Society for Testing Materials.[1]

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 800.

The varnished film shall show no evidence of disintegration in the oil nor flake either in the oil or on the blotter used in the test.

(*b*) The specimens tested for resistance to oil shall be used for electrical tests as described in Section 17.

Dielectric Strength, as Received

15. (*a*) Ten punctures shall be made on one specimen from each roll as received. The dielectric strength values are the puncture values in volts divided by the average of the ten thickness readings on the specimens in mils. The average of the ten dielectric strength values for each roll as received, shall conform to the requirements shown in Table I. The dielectric strength values when analyzed to determine the uniformity of the material shall conform to the requirements of Paragraphs (*b*) and (*c*).

(*b*) *Uniformity Within the Roll.*—The deviation factor for each roll in each shipment shall be not more than 0.11 when calculated from the following formula:

$$\text{Deviation factor of roll} = \frac{h - l}{h + l}$$

where h = the average of the five highest dielectric strength values of the roll, in volts per mil; and

l = the average of the five lowest dielectric strength values of the roll, in volts per mil.

TABLE I.—DIELECTRIC STRENGTH REQUIREMENTS FOR VARNISHED CLOTH TAPE.

	DIELECTRIC STRENGTH, MINIMUM AVERAGE VOLTS PER MIL		
NOMINAL THICKNESS	AS RECEIVED	AFTER ELONGATION	AFTER HOT OIL
Over 10 mils..............	1100	1000	950
9 and 10 mils, incl..........	1000	900	850
Under 9 mils..............	900	800	750

(*c*) *Uniformity of the Shipment.*—The deviation factor for each roll in each shipment shall be not more than 0.10 when calculated from the following formula:

$$\text{Deviation factor of shipment} = \frac{a - l}{a + l}$$

where a = the average dielectric strength of the entire shipment, in volts per mil; and

l = the average of the five lowest dielectric strength values of the roll, in volts per mil.

Dielectric Strength, After Elongation

16. Five punctures shall be made inside the gage length on each specimen after the elongation test specified in Section 13. The

average of the five dielectric strength values for each roll shall conform to the requirements shown in Table I.

Dielectric Strength, After Hot Oil

17. Five punctures shall be made on each specimen after the test for resistance to oil specified in Section 14. The average of the five dielectric strength values for each roll shall conform to the requirements shown in Table I.

PACKING AND MARKING

Packing

18. The purchaser shall specify whether tape is to be supplied dry or immersed in oil.

Dry Packing

19. In the case of dry tape, the purchaser shall specify the number of rolls per package and whether each roll shall be dipped or whether each package shall be dipped in a moisture-resistant wax or neither or both. The wrapping shall be secure and shall protect the contents.

Packing in Oil

20. Oil-immersed tape shall be supplied in suitable oil-tight cans with easily removable lids. The purchaser shall specify the number, width, and length of rolls and the type of oil to be supplied in each can.

Marking

21. The purchaser shall specify the marking desired on each package or can; unless the marking is definitely specified, the package shall conform with the usual trade customs.

INSPECTION AND REJECTION

Inspection and Testing

22. The material shall be inspected and tested within three weeks of its receipt by the purchaser.

Rejection

23. (*a*) The purchaser reserves the right to reject any part of the shipment that does not conform to the requirements for packing and marking as specified in Sections 19, 20 and 21.

(*b*) The failure of a sample roll to conform to the requirements of one or more of the sections enumerated under Paragraphs (*c*) and (*d*) shall be counted as only one roll failure.

(*c*) The failure of 35 per cent or more of the sampled rolls to conform to the requirements of Sections 3, 4, 5, 7, 8, 9, 10 and 11 shall constitute cause for rejection of the entire shipment without further tests.

(*d*) The failure of 50 per cent or more of the sampled rolls to conform to the requirements of Sections 12, 13, 14, 15, 16 and 17 shall constitute cause for rejection of the entire shipment.

Note.—The following illustrates a convenient method of recording failures of sampled rolls:

Roll No.	Failures Under Sections								Roll Failures
	3	4	5	7	8	9	10	11	
1				X					X
2				X	X				X
3									
4									
5									
6					X	X		X	X
7									
8									
9									
10									
Total rolls sampled = 10									Total failures = 3 rolls

Thirty per cent of the rolls failed; therefore, this shipment passes Paragraph (*c*).

Claims

24. Rejection claims shall be made to the seller in writing within four weeks of receipt of material by the purchaser. The results of tests made by the purchaser on which rejection is based shall be furnished to the seller, who shall, within one week of receipt of all such claims, either agree to satisfy the claim or send a representative to the plant of the purchaser to resample the shipment. Samples so selected shall be sealed and submitted to an umpire, mutually agreeable to the purchaser and seller, whose decision should be final.

Settlement of Claims

25. The expense of the umpire tests shall be paid by the loser. In the case of rejection being established, the seller shall pay the freight both ways on the rejected material.

TENTATIVE METHODS OF TESTING SOLID FILLING AND TREATING COMPOUNDS USED FOR ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 176 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1923; REVISED, 1924, 1925, 1929, 1933, 1934.

Scope

1. These methods cover physical and electrical tests for solid filling and treating compounds for electrical insulation.

PHYSICAL TESTS

General Physical Tests

2. Each of the following tests shall be made in accordance with the method of test applicable, of the American Society for Testing Materials, as indicated:

(*a*) *Melting Point:* Standard Method of Test for Melting Point of Petrolatum (A.S.T.M. Designation: D 127).[2]

(*b*) *Softening Point,* for compounds having no definite melting point: Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (A.S.T.M. Designation: D 36),[3] or Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (A.S.T.M. Designation: D 61).[4] The method used should be indicated in the report.

(*c*) *Flash and Fire Points:* Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92).[5]

(*d*) *Evaporation:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (A.S.T.M. Designation: D 6).[6]

(*e*) *Viscosity,* Temperature range from melting point to 150 C.: Saybolt Furol, Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (A.S.T.M. Designation: D 88).[7]

(*f*) *Penetration Test,* Temperature range from melting or softening point to −25 C.: Standard Method of Test for Penetration of Bituminous Materials (A.S.T.M. Designation: D 5).[8]

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 840.

[3] *Ibid.*, p. 984.

[4] *Ibid.*, p. 989.

[5] *Ibid.*, p. 800.

[6] *Ibid.*, p. 962.

[7] *Ibid.*, p. 880.

[8] *Ibid.*, p. 971.

Brittleness

3. To determine the brittleness of the material, the compound shall be spread on a piece of sheet metal in a layer $\frac{1}{16}$ in. in thickness. It shall then be submerged in water having a temperature at least 20 F. above the expected breaking point. It shall then be cooled 5 F. and held at this temperature for 5 minutes. The cooling shall then be continued in increments of 5 F. At each temperature interval the compounds shall be tested with the blade of a knife, inserting the point with the blade as nearly parallel with the sheet metal as is practicable, and pulling the compound from the sheet metal as rapidly as possible by rotating the blade about its back as an axis. The temperature at which the compound no longer stretches but snaps, shall be considered the breaking point.

COEFFICIENT OF EXPANSION

Scope

4. This test is intended to determine the true coefficient of expansion of solid filling and treating compounds. For many purposes the true coefficient of expansion is not as important as the effective coefficient of the compound and entrapped gases. However, consistent test results can only be obtained with gas-free compounds.

Method

5. For liquids, waxes and petrolatums, calibrated flasks of Pyrex or quartz shall be used (Method A). Asphalts and other opaque materials of high viscosity shall be tested in a calibrated metal cell (Method B). Regardless of the method used, air and other entrapped gases must be removed by de-gassification.

Method A. Using Glass Flask

Apparatus

6. (*a*) *Flask.*—The flask[1] shall hold approximately 250 ml. to the zero mark, and the neck of the flask shall be 1 cm. in internal diameter and graduated for 25 ml. in 0.1-ml. divisions.

(*b*) *Oil Bath.*—The cylindrical oil bath for heating the sample shall be approximately 10 in. (25.4 cm.) in inside diameter and 20 in. (50.8 cm.) in inside depth with a false bottom 1 in. from the bottom and shall have provision for circulating and heating the oil.

(*c*) *Lead Collar.*—A lead collar shall be hung on the flask during test to prevent the oil currents of the bath from moving the flask.

Calibration

7. The capacity of the flask at the zero point and several points on the scale shall be determined by filling the flask with distilled water at a known temperature and weighing.

---

[1] A Pyrex or quartz glass flask is very satisfactory for this purpose.

Procedure

8. (*a*) The flask shall be maintained under a vacuum of 25 in. of mercury and a temperature 50 C. higher than the softening point (ring-and-ball method, as determined under Section 2 (*b*)) while being filled and for approximately 30 min. after filling is complete. The flask shall be filled to within the last milliliter marked on the neck when held at the maximum test temperature and slowly cooled to room temperature (10 to 12 hr.). Before starting the test, the flask shall be examined for the presence of cavities or irregular contraction of the compound. Some compounds after cooling below the liquid state, tend to stick to the sides of the neck of the flask. In such cases it is necessary to gradually warm the neck and flow the compound to meet the rest, after which the flask shall be placed in the bath for several hours to insure temperature equilibrium.

(*b*) With the compound satisfactorily placed in the flask at the lowest temperature, the height of the column in the neck shall be read and the bath then slowly heated. Readings shall be taken at 50 C. intervals, holding the bath as constant as possible at each point until no more expansion occurs at that point, the procedure being repeated for each point until maximum temperature is reached.

(*c*) *Precautions.*—During the test, temperature readings shall be taken at top and bottom of the bath to detect any variation. Readings of the expansion of the compound shall be made at intervals long enough to insure uniform temperature distribution and complete movement of the compound. Until complete liquefaction, the interval should be 3 to 4 hr.; after liquefaction it may be reduced to 30 min.

Calculation

9. (*a*) After securing the readings over the temperature range desired, a curve shall be plotted from the temperature and expansion readings from which the coefficient of expansion shall be calculated from the following formula:

$$\text{Coefficient of expansion of the compound} = \frac{V_1 - V}{(T_1 - T)\,V} + C$$

where V = the original volume occupied by the compound;
V_1 = the volume at higher temperature occupied by the compound;
T = the original temperature;
T_1 = the higher temperature, and
C = a constant = coefficient of expansion of glass container

(*b*) The coefficient of expansion shall be calculated for three temperature ranges, as follows:

(*1*) From the minimum temperature at which the measurement was made to 10 C. below the melting point. This is intended to give the average coefficient for the solid condition.

(*2*) From 5 C. above the melting point to 100 C. This is intended to give the average coefficient for the liquid condition.

(*3*) From the minimum temperature at which a measurement was made to 100 C.

Method B. Using Metallic Cell

Apparatus

10. (*a*) *Metal Cell.*—The cell shall be made of steel, consisting of four parts, a cylinder about 2.5 in. in internal diameter, having a rigid bottom, a metallic gasket, a cover to which a steel capillary tube is attached and an auxiliary cover for introducing the compound to be tested while the cell is under a vacuum. The cell shall have an internal volume of approximately 250 ml. A metallic cell that has been found suitable is described in Appendix I.

(*b*) *Oil Bath.*—The oil bath shall be the same as described in Section 6 (*b*), Method *A*, with the exception that provision shall be made for supporting the metal cell.

Calibration

11. The cell shall be calibrated to determine its volume at various temperatures as follows:

(*a*) Weigh the assembled cell to determine its tare weight.

(*b*) Fill the cell with mercury until replacing the cover causes some to extrude through the capillary tubing. Record the weight of the cell and mercury and note the temperature.

(*c*) Place cell in the oil bath in an inverted position. The capillary tubing should extend over the side of the oil bath in such a way that the extruded mercury may be caught in a beaker. The oil bath which is several degrees above room temperature causes some mercury to be extruded from the capillary tube. When all expansion has taken place, weigh the mercury collected.

(*d*) Adjust the oil bath for other test temperatures and note the amounts of mercury extruded. The weight of mercury in the cell at any temperature is thus determined and the volume may be calculated.

Procedure

12. (*a*) The cell shall be fitted with the auxiliary cover and held in an upright position in the oil bath while filling. A vacuum of 25 in.

of mercury and a temperature 50 C. higher than the softening point (ring-and-ball method, as determined under Section 2 (*b*)) shall be maintained while filling and for at least 30 min. after the cell has been filled to within approximately $\frac{1}{4}$ in. of the cover. The cell shall then be slowly cooled to room temperature, and any irregularities in the surface of the compound removed.

(*b*) The auxiliary cover shall be replaced with the standard cover and the cell and compound weighed.

(*c*) Sufficient mercury shall be poured into the cell so that some is extruded when the cover is screwed down. The cell shall then be weighed again.

(*d*) The cell shall then be inverted and placed in the oil bath, and the procedure outlined under calibration, Section 11 (*c*) and (*d*) again followed for 5 C. intervals.

(*e*) *Precautions.*—Only clean, distilled mercury shall be used. During the test, temperature readings shall be taken at top and bottom of the bath to detect any variation. Readings of the expansion of the compound should be made at intervals long enough to insure uniform temperature distribution and complete movement of the compound. Until complete liquefaction, the interval should be 3 to 4 hr.; after liquefaction, it may be reduced to 30 min.

Calculation

13. (*a*) After volumetric determinations have been made over the desired temperature range, a curve shall be plotted between volume and temperature readings from which the coefficient of expansion shall be calculated from the following formula:

$$\text{Coefficient of expansion of the compound} = \frac{V_1 - V}{(T_1 - T)\,V}$$

where V = the original volume occupied by the compound;
V_1 = the volume at higher temperature occupied by the compound;
T = the original temperature, and
T_1 = the final temperature.

(*b*) The coefficient of expansion shall be calculated for the same three ranges as prescribed in Method *A*, Section 9 (*b*).

Report

14. The report shall include the following:

(*a*) The type of cell used.

(*b*) A copy of the volume-temperature curve.

(*c*) The temperature ranges as defined under Section 9 (*b*) or 13 (*b*).

(*d*) The coefficient of expansion corresponding to each of the three temperature ranges.

ELECTRICAL TESTS

DIELECTRIC STRENGTH TEST

Dielectric Strength

15. (*a*) This test is intended to determine the dielectric strength of solid filling and treating compounds under voltage stresses of short duration. It is of value as a comparative test but does not indicate the permanent dielectric strength of these compounds.

(*b*) The dielectric strength of this class of material varies with the temperature. It is, therefore, recommended that a sufficient number of tests be made at different temperatures to establish the momentary dielectric strength-temperature curve from 0 to 100 C.

Sample

16. A representative sample shall be taken from the original package, melted and poured directly into the testing container. Care should be exercised in melting and pouring the compound not to overheat it nor to entrap air. A melting and pouring temperature of approximately 50 C. above the softening point (ring-and-ball method) as determined under Section 2 (*b*) is recommended. The electrodes shall be heated to the approximate temperature of the compound before filling the container.

Electrodes

17. (*a*) The testing container, after filling, shall be placed in a suitable constant-temperature air bath or oil bath and sufficient time allowed to elapse to bring the entire mass to a uniform temperature. The temperature shall be determined by a thermocouple attached to one of the metal electrode ends or by a mercury thermometer placed vertically touching an electrode and approximately ½ in. (1.25 cm.) from the gap between electrodes.

(*b*) The test shall be made between polished hemispherical (Note 1) brass or copper electrodes ½ in. in diameter separated by a gap of 0.1 in. (Note 2).

NOTE 1.—A convenient form of apparatus for holding the electrodes and compound is described in Appendix II. It is recognized that when liquid materials are being tested, this method is inconsistent with the Standard Methods of Testing Electrical Insulating Oils (A.S.T.M. Designation: D 117) of the American Society for Testing Materials.[1] However, since spherical electrodes are considered preferable for solid and semisolid materials, the advantage of using spherical electrodes for all splicing compounds, whether liquid or solid, so that direct comparison can be made, is sufficiently great to justify the inconsistency with Methods D 117.

NOTE 2.—In the case of materials which cannot be broken down with the available voltage, the gap may be reduced to 0.05 in. but results will not be comparable directly with those obtained with the 0.1-in. gap.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1087.

Testing Transformer Voltage Control and Measurement

18. (*a*) The testing transformer used, methods of voltage control and measurement shall be as outlined in Section 2 of the Tentative Methods of Testing Sheet, Tape and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 - 34 T) of the American Society for Testing Materials.[1]

(*b*) The actual gap at the test temperature shall be determined by direct measurement or by measurement at some other temperature and computation of changes due to expansion or contraction.

Number of Specimens

19. Five specimens at a given temperature shall be tested and the average value taken as the momentary dielectric strength of the compound at that temperature.

Report

20. The report shall include the following:

(*a*) The momentary dielectric strength - temperature curve;

(*b*) The individual values of the puncturing voltage and the gap length at the various temperatures.

VOLUME RESISTANCE - TEMPERATURE CHARACTERISTICS

Volume Resistance versus Temperature

21. (*a*) This test is intended to determine the volume resistance - temperature characteristics of solid filling and treating compounds. It is of value as a comparative test and also may be used in determining the volume resistivity on an ohm-centimeter basis.

Temperature Range

(*b*) The volume resistance of this class of material varies with the temperature, generally decreasing rapidly with increase of temperature. It is, therefore, recommended that a sufficient number of tests be made at different temperatures to establish the volume resistance - temperature curve. To be of most significance, the test shall include determinations made up to the highest service temperatures. At room temperatures and below, the volume resistance of practically all of these compounds is so high that it cannot be measured with the ordinary galvanometer equipment.

Conductivity Cell

22. A suitable conductivity cell consisting of parallel planes, concentric cylinders, or coaxial cones shall be used in determining the volume resistance of the compound. The distance between

---

[1] See p. 983.

electrodes shall not be less than 0.75 mm. (0.03 in.) nor more than 5 mm. (0.2 in.). The voltage gradient shall not exceed 200 v. per millimeter (5 v. per mil). The area of the electrode shall be sufficiently large so that the current flow can be measured, with the apparatus available, to an accuracy within 5 per cent. Electrode areas of 50 to 500 sq. cm. (7.7 to 77.5 sq in.) should prove suitable. Because of possible catalytic or corrosion effects of some compounds on certain metals, the electrodes should be nickel, gold or platinum plated.

The insulating material used to support the electrodes shall be capable of withstanding the wide temperature range to which the cell is subjected and preferably shall be of an inorganic material such as a ceramic material or suitable glass.

A test run on the empty cell shall be made over the temperature range chosen in order to determine if any leakage is present.

A conductivity cell that has been found suitable is described in Appendix III.

Sample

23. (*a*) A representative sample shall be taken from the original package, melted and poured directly into the testing container. Care shall be exercised in melting and pouring the compound not to overheat nor to entrap air in it. A melting and pouring temperature of approximately 50 C. above the softening point (ring-and-ball method) as determined under Section 2 (*b*) is recommended. The quantity of the sample depends upon the capacity of the resistivity cell used, but in any case it shall be sufficient to permit three separate determinations. Before filling, the conductivity cell shall be heated to slightly above the pouring temperature of the compound.

(*b*) A suggested procedure in filling the cell, especially in the case of the higher melting compounds, is to determine the quantity of compound necessary to just fill the cell with the electrodes in position. In the case of coaxial cones or concentric cylinders the proper quantity of the heated compound shall be first poured slowly into the outer cylinder. Any bubbles which may form on the surface of the compound shall be removed by a quick application of a flame from a bunsen burner. Immediately the inner electrode shall be slowly lowered into the compound and a thermometer placed in the well.

Test

24. The conductivity cell, after filling, shall be placed in an oil or air bath having suitable temperature control and sufficient time allowed to elapse to bring the bath and cell to temperature equilibrium

at each test temperature. The temperature of the cell shall be determined by two mercury thermometers placed in contact with the electrodes. The temperature of the bath shall be determined by a mercury thermometer placed near the cell. The temperature of the bath shall be within 1 C. of the test temperature when readings are taken. The temperatures of the cell thermometers shall agree within 0.5 C. of each other and within 1 C. of the bath temperature when readings are taken.

Measurements and Calculations

25. The volume resistance shall be measured at each temperature in accordance with the Standard Methods of Test for Resistivity of Insulating Materials (A.S.T.M. Designation: D 257) of the American Society for Testing Materials,[1] with particular attention to Sections 8, 9, 10, 17, 18 and 19 for liquid insulating materials.

Report

26. The report shall include the following:

(*a*) The type of resistivity cell used;

(*b*) The distance between guarded and unguarded electrodes;

(*c*) The area of guarded electrode;

(*d*) The battery voltage; and

(*e*) A curve plotted from the readings obtained over the temperature range chosen showing the relation of volume resistance in ohm-centimeter units and the temperature in degrees Centigrade.

NOTE.—In lieu of the information required in Paragraphs (*b*) and (*c*), a statement of the approximate overall accuracy may be made.

POWER FACTOR AND DIELECTRIC CONSTANT

Scope

27. This test is intended to determine the power factor and the dielectric constant of solid filling and treating compounds at specified temperatures corresponding to those temperatures to which the materials are to be subjected in service.

Temperature Range

28. Since the power factor and dielectric constant of this class of materials vary with the temperature, a sufficient number of tests shall be made at different temperatures to establish the dielectric constant - temperature curve and the power factor - temperature curve over the temperature range to which the respective material is subjected in service. Determinations shall be made at not less than three temperatures; a temperature near the lowest to which the material is to be subjected in service, ordinary room temperature of 20 to 25 C., and a temperature near the maximum temperature to which it is subjected in service.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1107.

NOTE.—For many materials the power factor - temperature curve may have a maximum, minimum, or other irregularity within the working range of temperatures. With such a material many determinations may be required to establish the curve.

Test Specimens

29. The materials to which these tests apply fall into two classes as regards the most suitable type of specimen to be used in the measurement of power factor and dielectric constant. One class includes waxes and other materials which can be cast or pressed into sheet form and then measured between electrodes, such as are used in making tests on porcelain, molded materials and sheet materials. (See the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (A.S.T.M. Designation: D 150 - 34 T) of the American Society for Testing Materials.[1]) The other class includes materials that are fluid at ordinary temperature or can be made so by increasing their temperatures. Materials in the fluid state can be poured into a measuring cell such as described in Section 34 and the determinations made from which the power factor and the dielectric constant can be calculated.

Measuring Cell

30. In the measuring cell the distance between the electrodes and the area of the electrodes shall be such that a capacitance of not less than 100 $\mu\mu$f. will be obtainable. The voltage gradient shall not be over 5 v. per mil. Due to the catalytic or corrosive effects of some compounds on certain metals, the electrodes may need to be nickel, gold, or platinum plated. The insulating material used to support the electrodes shall be capable of withstanding the wide temperature range to which the cell or material is to be subjected during the tests without any appreciable effect upon the determinations being made. Certain ceramic materials, special glasses, and quartz have been found suitable for insulating supports for the electrodes between which the material is to be measured. One cell that has been found satisfactory for these determinations is described in Appendix III. Cells of different construction from the one described have been used with equally satisfactory results.

Sampling

31. A representative sample shall be taken from the original package, melted if necessary, and then either cast in the form of a disk or poured directly into the measuring cell. The use of the cell or the disk will depend upon the particular material. In heating and pouring the compound, care shall be exercised not to entrap air in

---

[1] See p. 1029.

the compound between the electrodes. A melting and pouring temperature of approximately 50 C. above the softening point (ring-and-ball method, as determined under Section 2 (*b*)) is recommended. A sufficient quantity of the material shall be taken as the sample to enable making at least three determinations. Before pouring the compound into the container or cell, the container or cell shall be heated to a temperature slightly higher than the temperature at which the compound is being poured.

Temperature Bath

32. The specimen as prepared above, shall be placed in an oil or air bath having suitable temperature control, and sufficient time allowed to elapse to bring the bath and specimen to the desired temperature equilibrium at each test temperature. The temperature of the electrodes and the compound shall be determined by two mercury thermometers, or two thermocouples with cold junctions placed in contact with the electrodes. The temperature of the bath shall be determined by a thermometer, or a thermocouple with cold junction placed near the cell or the specimen. The temperature of the bath shall be within 1 C. of the desired test temperature when the determinations are made. The temperature of the specimen thermometers or thermocouples shall agree within 0.5 C. of each other and within 1 C. of the bath temperature when the readings are taken.

Measurements

33. Determinations shall be made of the power factor and dielectric constant at the temperatures and frequencies desired in accordance with the methods outlined for 25 to 60 cycles, 1000 cycles and 100 to 1500 kilocycles as described in the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (A.S.T.M. Designation: D 150 - 34 T) of the American Society for Testing Materials.[1] Measurements shall be made at the frequencies to which the material will be subjected in service unless otherwise specified. When using a cell in making power factor and dielectric constant determinations, measurements shall be made at the temperature desired, first with air as dielectric and then with the compound in the cell as dielectric.

Calculations

34. The power factor shall be calculated in accordance with the Tentative Methods D 150 - 34 T,[1] and the dielectric constant shall be determined for any given compound from the ratio of the capaci-

---

[1] See p. 1029.

tance of the cell with the compound as dielectric to the capacitance of the cell with air as dielectric. When the specimen under determination is in the form of a disk the air capacitance shall be calculated from the dimensions of the electrodes and the thickness of the dielectric. In this case, correction shall be made as outlined in the Tentative Methods D 150 - 34 T.[1] When the sample has been poured between electrodes being held apart by separators, the air capacitance can be measured directly the same as with the cell, or it may be calculated from the dimensions of the electrodes and the thickness of the separators, taking into account the edge correction.

Report

35. The report shall include the following:

(*a*) The type of cell used and the dimensions of the same.

(*b*) The method used and the frequency at which measurements were made.

(*c*) The voltage across the specimen during the test.

(*d*) The dielectric constant, the power factor, and the respective temperatures at which the determinations were made.

(*e*) A statement of the approximate accuracy of the determinations.

---

[1] See p. 1029.

APPENDIX I

CELL FOR DETERMINING COEFFICIENT OF EXPANSION OF SOLID FILLING AND TREATING COMPOUNDS

Figure A1 shows the metallic cell for coefficient of expansion determinations. The cell consists of four principal parts: A steel cylinder, a metallic gasket, a steel cover, and a dummy or auxiliary cover for filling. The gasket must be of a metal which does not amalgamate with mercury.

The cylinder is about 2.5 in. (6.35 cm.) in internal diameter, and approximately 3 in. (7.6 cm.) in internal depth. The top of the cylinder is threaded to receive the steel cover and has a machined shoulder to seat a 0.003 in. thick metallic gasket. The cylinder may be of one piece construction or fitted with a cap at the bottom similar to the top end.

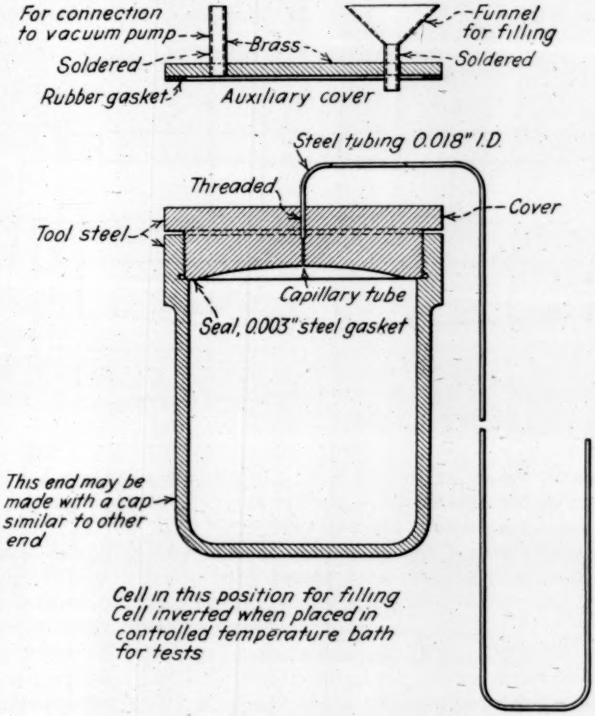

For connection to vacuum pump
Brass
Funnel for filling
Soldered
Soldered
Rubber gasket
Auxiliary cover
Steel tubing 0.018" I.D.
Threaded
Cover
Tool steel
Capillary tube
Seal, 0.003" steel gasket
This end may be made with a cap similar to other end
Cell in this position for filling Cell inverted when placed in controlled temperature bath for tests

FIG. A1.—Metallic Cell for Coefficient of Expansion Determinations.

The steel cover is carefully rounded on the under side to avoid air pockets. It is threaded into the top of the cylinder and seats on the metallic gasket. The center of the cover is threaded to receive a steel capillary tube of 0.018 in. in internal diameter.

The auxiliary cover is brass with a rubber gasket seated by atmospheric pressure. A brass funnel and vacuum connection are soldered to the cover. A plug is provided for sealing the funnel while the cell is maintained under the vacuum specified after filling.

APPENDIX II

DEVICE FOR DETERMINING DIELECTRIC STRENGTH OF SOLID FILLING AND TREATING COMPOUNDS

Because of the great difficulty experienced in removing most solid filling and treating compounds from the container and from the electrode an arrangement is desirable which is sufficiently inexpensive to permit of its being discarded fully or in part after the test. Two devices that have proved satisfactory are illustrated in Figs. A2 and A3.

Figure A2 shows the simplest device. It consists of a box about 2 in. square in cross-section and 2 in. in length inside of the wooden ends. The sides and bottom are made from a single piece of press board and are attached to wooden blocks which form the ends. Holes drilled through the wooden blocks receive the electrodes which are turned from ½ in. diameter brass rod. To facilitate adjustment of the gap length, a gage is arranged to slip over the ends of the electrode and so regulate the gap to the desired value.

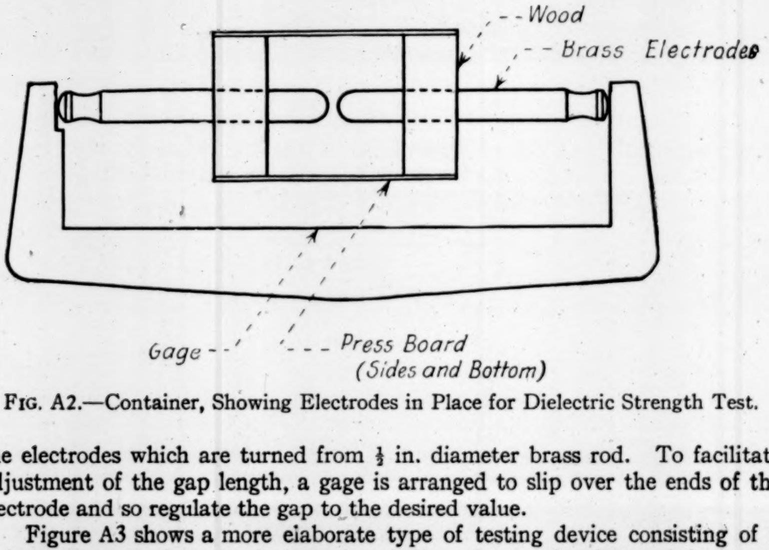


FIG. A2.—Container, Showing Electrodes in Place for Dielectric Strength Test.

Figure A3 shows a more elaborate type of testing device consisting of a framework made from laminated phenol fiber about 8 in. (20 cm.) in length and 2¼ in. (5.7 cm.) square with brass bushings centrally inserted in each end member to hold the electrode rods. A box of heavy paper or pasteboard is arranged to fit loosely inside the framework. The electrodes, which are separable by means of screw joints, are inserted through small holes in the ends of the paper box and clamped to make an oil-tight joint. The proper electrode spacing may be obtained by means of an adjusting screw on the right-hand end. Changes in the electrode spacing with temperature can be reduced greatly (to less than 0.001 in. in a change of temperature of 75 C.) by the indicated electrode design. Phenol fiber of suitable coefficient of expansion is used for supporting the brass hemispherical electrode tips and electrical connection is made by a copper wire through the center of the fiber rod. The volume of the container may be reduced to accommodate small samples by the insertion of wedges of carefully dried wood into the corners of the paper box.

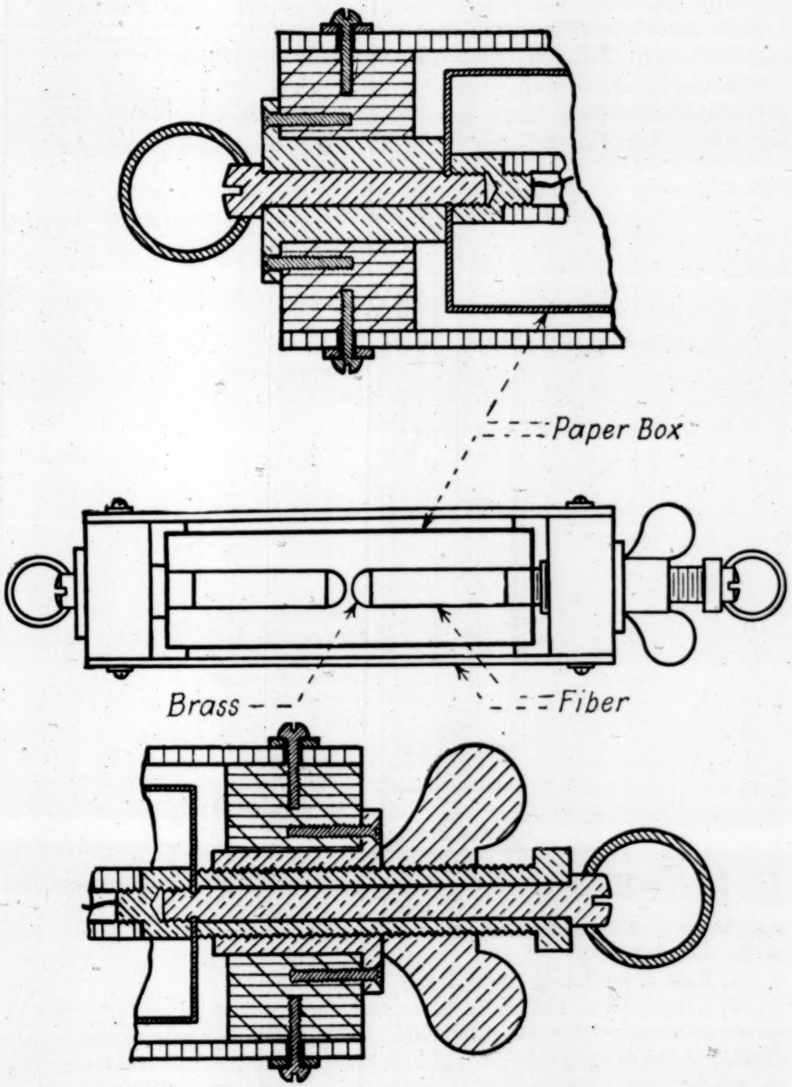

Paper Box
Brass
Fiber

FIG. A3.—Container, Showing Electrodes in Place for Dielectric Strength Test.

APPENDIX III

MEASURING CELL FOR RESISTIVITY, POWER FACTOR AND DIELECTRIC CONSTANT MEASUREMENTS OF SOLID FILLING AND TREATING COMPOUNDS

A conductivity cell that has been developed for the purpose of measuring the volume resistivity as well as other electrical constants of solid filling and treating compounds and oil is shown in Fig. A4. The concentric cylinder type of cell was chosen after experimenting with various types for the following points of simplicity and efficiency:

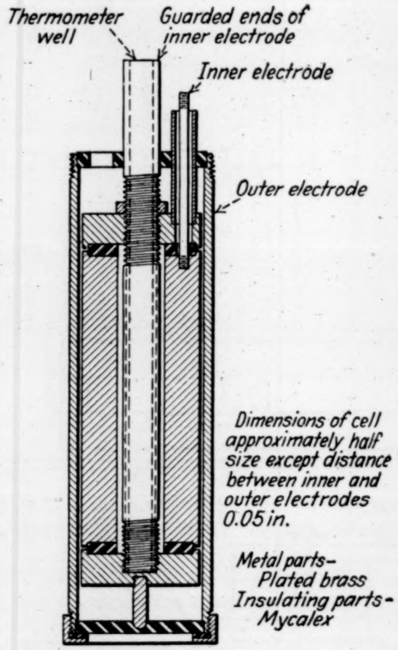

Thermometer well
Guarded ends of inner electrode
Inner electrode
Outer electrode
Dimensions of cell approximately half size except distance between inner and outer electrodes 0.05 in.
Metal parts–Plated brass
Insulating parts–Mycalex

FIG. A4.—Apparatus for Volume Resistance - Temperature Characteristics Test.

1. Ease of insulating electrodes.
2. Large area of electrodes in compact form, the outer one of which also serves as container for the compound. This outer electrode is also exposed directly to the heating medium and aids in rapid changes from one temperature to another and also promotes uniform temperature distribution to the comparatively thin layer of compound in contact with it.
3. Comparative ease in assembling and disassembling cell and cleaning.

This type of cell permits the use of a very small amount of insulating material to insulate the electrodes. Mycalex has been found to be a satisfactory material for this purpose due to the fact that it can be machined to size and has good insulation resistance characteristics over the temperature range at which these compounds are normally tested. Also, it apparently is unaffected by the solvents used in the cleaning operation.

A suggested method of cleaning the cell is to remove the bottom retaining ring and to hang the cell in an oven by a hook fastened through a hole drilled in the protruding stem. Upon heating, the outer cylinder will slide away from the inner electrode and both parts will drain fairly clean of the compound. In order to speed up this cleaning, the flame of a bunsen burner may be applied directly to the cell after removing the cap and suspending the cell by the protruding stem. Further application of the flame to the cylinder and inner electrode after they separate will rapidly remove most of the compound and the final cleaning of each part can be accomplished by suitable solvents.

TENTATIVE METHODS OF TESTING SHEET, TAPE, AND MOLDED INSULATING MATERIALS FOR DIELECTRIC STRENGTH[1]

A.S.T.M. Designation: D 149 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1922; REVISED, 1923, 1924, 1926, 1927, 1930, 1931, 1932, 1933, 1934.

Scope

1. (*a*) These methods are intended to determine the dielectric strength of sheet, tape and molded insulating materials except rubber insulating tape which should be tested in accordance with the Tentative Specifications and Tests for Rubber Insulating Tape (A.S.T.M. Designation: D 119 - 34 T) of the American Society for Testing Materials,[2] and friction tape for electrical purposes which should be tested in accordance with the Tentative Specifications and Tests for Friction Tape for General Use for Electrical Purposes (A.S.T.M. Designation: D 69 - 34 T) of the American Society for Testing Materials.[3]

Types of Tests

(*b*) Since the dielectric strength of sheet, tape, and molded materials is dependent upon the time of application of the electrical tension, three tests differing in time duration are included as follows:

A. *Short-Time Dielectric Strength Test.*
B. *One-Minute Step-by-Step Dielectric Strength Test.*
C. *Endurance Dielectric Strength Test.*

NOTE.—Method C shows the relative dielectric strength of different flexible sheet, tape and molded insulating materials at high temperature when subjected to electrical tensions for relatively long periods.

Sheet Materials

(*c*) Sheet materials are divisible into two general classes: (*1*) thin, flexible materials, easily bent or wrapped around conductors, and (*2*) stiff sheet and plate materials, slightly flexible or rigid.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] See p. 1145.

[3] See p. 1139.

(*1*) Tests on thin, flexible materials at room temperature shall be made in accordance with Method *A* Short-Time Dielectric Strength Tests as specified in Sections 3 to 12; with Method *B* One-Minute Step-by-Step Dielectric Strength Test as specified in Sections 13 to 21, or with Method *C* Endurance Dielectric Strength Test as specified in Sections 22 to 26.

(*2*) Tests on stiff sheet and plate materials at room temperature shall be made in accordance with the special instructions covered under Dielectric Strength Tests on Stiff Sheet and Plate Materials in Sections 27 to 31.

Molded Materials

(*d*) Tests on molded materials at room temperature shall be made in accordance with the special instructions prescribed for Dielectric Strength Tests on Molded Materials in Sections 32 to 36.

APPARATUS

High-Voltage Transformer

2. (*a*) Any well-designed, high-voltage transformer connected to an alternating current supply, having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall be not less than 2 kva. for voltages of 50,000 v. or less, and not less than 5 kva. for voltages above 50,000 v. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high-tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point and in no case more than 500 v. at a step. The control may be made by generator field regulation, with an induction regulator, or with a variable ratio auto transformer, Any method of regulating the voltage is satisfactory which does not distort the wave more than 10 per cent from a sinusoidal shape.

(*c*) The voltage may be measured by any approved method which gives root-mean-square values, preferably by means of a voltmeter connected to a special voltmeter coil in the high-tension winding of the testing transformer, or to a separate step-down instrument potential transformer. A voltmeter on the low-tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high-tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

(*d*) Some protection is desirable in the high-tension circuit of testing transformers where the potential is 25,000 v. or over, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils is used in series with the high-tension terminals, it should not be greater than that which will limit the high-tension current to double the normal rated current of the testing transformer.

When a spark gap is used, a non-inductive resistance of about one ohm per volt should be inserted in series with one terminal of the spark gap, to damp high-frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible. If the test is made with one side grounded, this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded, the resistance shall be inserted one-half on each side of the spark gap. Water tube resistors are preferable to carbon for this purpose, as carbon resistance may be materially decreased by the passage of current.

(*e*) The apparatus used and the method of measuring the voltage shall meet the requirements of the Standards of the American Institute of Electrical Engineers.

A. Short-Time Dielectric Strength Test

Electrodes

3. The electrodes shall be of brass or copper with flat polished contact surfaces, as follows:

(*a*) For sheet and plate materials the electrodes shall be cylinders 2 in. (50.8 mm.) in diameter and 1 in. (25.4 mm.) in length with the edges rounded to a radius of $\frac{1}{4}$ in. (6.35 mm.).

(*b*) For tapes the electrodes shall be cylindrical rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.) and the upper movable one shall weigh 0.1 lb. ± 0.005 lb. (45.4 g. ± 2.3 g.).

(*c*) For molded materials the electrodes shall be cylinders 1 in. (25.4 mm.) in diameter and 1 in. (25.4 mm.) in length with the edges rounded to a radius of $\frac{1}{8}$ in. (3.18 mm.).

NOTE.—Since the apparent dielectric strength of a material varies with the area of the electrodes used in making the test, results obtained with these different electrodes are not comparable.

TEST SPECIMENS

Test Specimens

4. (*a*) The test specimens may be of any convenient size, but the total area of the specimens of one sample of material shall be sufficient to permit making at least ten satisfactory tests.

(*b*) The specimens shall be representative of the material to be tested, care being taken to select material which is free from abnormal defects such as blisters, wrinkles, cracks, etc.

PROCEDURE

Surrounding Medium

5. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes

6. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen

7. (*a*) The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

(*b*) The electrodes shall be so mounted as to preclude any surface burning of the tape whatever and to prevent flashovers. If flashovers occur either over the edge of the tape or from the upper electrode to an adjacent lower electrode, or if the punctures in the tape are accompanied by a burning or charring of the surface of the tape, all the voltage readings obtained in making the test will not be reliable and shall be discarded and a new specimen tested.

8. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix two devices are shown which have been found satisfactory for use in testing tapes.

Application of Voltage

9. Starting at zero, the voltage shall be increased uniformly to breakdown at a rate of 0.5 kv. per sec., except that if breakdown occurs at this rate in less than 40 sec., the rate shall be decreased so that breakdown will occur in not less than 40 sec. If the material fails at less than 5 kv., the minimum time shall be reduced from 40 sec. to 20 sec.

Number of Tests

10. Unless otherwise specified, ten tests shall be made and the average of these ten puncturing voltages shall be taken.

Thickness

11. (*a*) The number of thickness readings on the specimen shall be at least equal to the number of punctures made in accordance with Section 10.

NOTE.—The micrometers and mode of operation specified in the Tentative Methods of Test for Thickness of Solid Electrical Insulation (A.S.T.M. Designation: D 374 - 34 T) of the American Society for Testing Materials[1] are suitable for this purpose.

(*b*) In the cases of sheet material and molded material, the thickness shall be measured near the point of puncture.

(*c*) In the case of tapes, Method B[1] of the Tentative Methods D 374 - 34 T shall be used. The readings shall be distributed along the center line of the specimen in such manner as to represent closely the thickness at the point of puncture. The average of these readings shall be the thickness used in calculating dielectric strength.

Report

12. Unless otherwise specified, the report shall include the following:

(*a*) The thickness of the specimen as determined in Section 11;
(*b*) Total volts at each puncture;
(*c*) Volts per mil of thickness for each puncture;
(*d*) The average, maximum, and minimum volts per mil of thickness for each sample;
(*e*) The room temperature;
(*f*) The relative humidity, in per cent; and
(*g*) The duration of the test.

B. One-Minute Step-by-Step Dielectric Strength Test

TEST SPECIMENS

Test Specimens

13. The test specimens shall be as specified in Section 4.

PROCEDURE

Surrounding Medium

14. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes

15. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen

16. The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

---

[1] See p. 1069.

17. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix are shown two different devices which have been found satisfactory for use in testing tapes.

Application of Voltage

18. An initial voltage shall be applied equal to 40 per cent of the breakdown voltage in the short-time test, adjusted as shown in the following table. The voltage shall then be increased in increments as indicated in the table, up to failure, being held at each step for 1 min. The change from each step to the next higher shall be made within 10 sec.

BREAKDOWN KILOVOLTS BY SHORT-TIME METHOD	ADJUST 40 PER CENT OF BREAKDOWN VOLTAGE TO NEAREST	INCREMENT OF INCREASE
12.5 kv. or less	0.5 kv.	0.5 kv.
over 12.5 to 25 kv., inclusive	1.0 kv.	1.0 kv.
over 25 to 50 kv., inclusive	2.5 kv.	2.5 kv.
over 50 to 100 kv., inclusive	5.0 kv.	5.0 kv.
over 100 kv	10.0 kv.	10.0 kv.

NOTE.—*Example:*

Breakdown voltage by short-time method = 41 kv.
40 per cent of breakdown voltage = 16.4 kv.
Initial voltage obtained by adjusting 40 per cent of breakdown voltage to nearest 2.5 kv. = 17.5 kv.
Voltage will be increased in increments of 2.5 kv.
Therefore, second step = 20.0 kv., etc.

Number of Tests

19. Five tests shall be made and the average of these five puncturing voltages shall be taken.

Thickness

20. The thickness of the specimen shall be measured in accordance with Section 11.

Report

21. Unless otherwise specified, the report shall include the following:

(*a*) The thickness of the specimen as determined in Section 11;
(*b*) Total volts at each puncture;
(*c*) Volts per mil of thickness for each puncture;
(*d*) The average, maximum, and minimum volts per mil of thickness for each sample;
(*e*) The room temperature;

(*f*) The relative humidity, in per cent;

(*g*) The duration of the test; and

(*h*) The value of the initially applied voltage and the value of the voltage at each step.

C. Endurance Dielectric Strength Test

Test Specimen

22. (*a*) The specimens shall be made by wrapping the material, in tape form with one-quarter lap, one-half lap, butt jointed or as sheets on brass tubes. The tubes shall be, for sheets and for tape up to 1½ in. in width, about 36 in. in length and 1 in. in outside diameter. For tapes wider than 1½ in., the tubes shall be 2 in. in outside diameter. The sample shall be built up to the desired thickness, simulating practical conditions, winding all layers of tape in the same direction.

(*b*) A smooth layer of metal foil shall then be wrapped over the insulation for a distance of 24 in., leaving 6 in. of insulation uncovered at each end of the tube. The metal foil shall be bound in place with a wrapping of adhesive tape which shall extend the full length of the tube in order to protect the insulation at the end from corona discharge.

(*c*) A thermocouple shall be applied to the metal foil near the center of the tube and held in place by the adhesive tape.

PROCEDURE

Position of Specimen

23. The specimen shall be mounted in an oven and a temperature of 100 C. (212 F.) maintained during the test. Provision shall be made for so mounting the specimen that the tube may be connected to the high voltage side of the circuit with the metal foil sheath and thermocouple connected to ground.

Application of Voltage

24. A voltage equal to 10 per cent of the breakdown voltage (to the nearest kilovolt) obtained in the short-time test (Method *A*) shall be applied and maintained for 30 min. The voltage shall then be increased by steps of 20 per cent of the initial value until puncture occurs, the voltage being held at each step for 30 min.

Temperature Readings

25. The temperature of the sample as indicated by the thermocouple shall be observed at intervals during the test and recorded at the end of each 30-min. period. It will be found that the temperature rises gradually until just before breakdown when the temperature increases rapidly. During this latter period, temperature readings shall be recorded at frequent intervals.

Report

26. The results shall be plotted using time, expressed in hours, as abscissas, and temperature, in degrees Centigrade, as ordinates. In addition to time as abscissas, the values of applied kilovolts shall be indicated since the value of kilovolts increases uniformly with time. The significant values to be taken from the curve and reported are:

(*a*) Duration of test;
(*b*) Breakdown voltage;
(*c*) Temperature of specimen at breakdown; and
(*d*) Rate of temperature rise during test.

The report shall also include a description of the specimen and its preparation, the thickness of the insulation and the number of layers of insulation.

Dielectric Strength Tests on Stiff Sheet and Plate Materials:

27. For testing stiff sheet and plate materials the procedure described in Method *A*, Short-Time Tests, Sections 2 to 12, and Method *B*, Step-by-Step Test, Sections 13 to 21, shall be modified in accordance with Sections 28 to 31.

Surrounding Medium

28. All tests shall be made under oil maintained at normal room temperature.

Conditioning

29. Exposure to humidity has little effect on dielectric strength as long as the relative humidity is below 85 per cent. It is not necessary to condition specimens or to test them under specified relative humidities when materials are intended for use where the relative humidity does not exceed 85 per cent.

Position of Electrodes and Specimen

30. Tests may be transverse or parallel to the flat sides, or both, depending upon whether the stress on the material when in use is to be transverse or parallel to the flat sides, or both.

(*a*) Transverse tests shall be made between the standard 2-in. electrodes (Section 3 (*a*)).

NOTE.—Surface creepage and flashover at the higher voltages may be prevented by pouring around the electrodes any high-grade insulating compound which will form a good bond with the material and with the electrodes. Sealing wax and phenolic resin varnish have been successfully used under certain conditions. In applying this protective compound, care must be taken to prevent voids under the edges of the electrodes.

(*b*) For tests parallel to the flat sides, the material shall be cut into sections 2 in. square. Holes shall be drilled into opposite edges of each section so as to line up with each other, the inner ends of the holes being ½ in. apart. Metal electrodes shall be used, the ends of which exactly fit the ends of the holes. Thus, in effect, the material is tested edgewise in a modified needle gap. The diameter of hole should be approximately one-fourth the thickness of the specimen. For very thin specimens it may be necessary to use a larger ratio of drill size. Results shall be expressed in total kilovolts breakdown.

Number of Tests

31. For the Short-Time Method five tests shall be sufficient, and for the Step-by-Step Method, three tests.

Dielectric Strength Tests on Molded Materials:

32. For testing molded materials the procedure described in Method *A*, Short-Time Tests, Sections 3 to 12, and Method *B*, Step-by-Step Test, Sections 13 to 21, shall be modified in accordance with Sections 33 to 36.

Surrounding Medium

33. It is recommended that all tests on hot-molded materials be made under oil and tests on cold-molded materials in air.

Test Specimen

34. (*a*) The test specimen shall be molded in the form of a disk 4 in. (10.16 cm.) in diameter which shall be ⅛ in. (3.18 mm.) in thickness for hot-molded materials and ¼ in. (6.35 mm.) in thickness for cold-molded materials.

NOTE.—To permit the use of one mold for all molding compounds the following variations in dimensions of the test specimen will be permissible:

For hot-molded compounds	± 5 per cent
For cold-molded compounds	± 10 per cent

Position of Electrodes

(*b*) Tests shall be made between the standard 1-in. electrodes (Section 3 (*c*)) located at the center of the specimen.

Number of Tests

35. For the Short-Time Method five tests shall be sufficient, and for the Step-by-Step Method, three tests.

Tests After Water Immersion

36. Three specimens shall be punctured after they have had the rim immersed in melted paraffin for a depth of 1 in. (25.4 mm.) and

have been entirely immersed in water for 48 hr. at normal room temperature of about 20 C. (68 F.). The surface of the specimen shall be wiped off with a dry cloth to remove all trace of excessive surface moisture and the puncture tests made immediately.

Tests at Different Temperatures:

37. Where the test materials are to be used at other than room temperature, their dielectric strength characteristic should be ascertained over the operating range of temperature.

Apparatus

38. Temperature control shall be obtained by the use of an air oven (or refrigerator) in the case of thin and cold-molded materials, or by the use of an oil bath, in the case of stiff sheet and plate, and hot-molded materials.

(*a*) The air oven should be provided with some means of circulating the air, so that approximately constant temperature is maintained around the test specimen, and with a thermometer or thermocouple for measuring the temperature as near the point of test as practicable. Any well-designed oven of sufficient size to hold the test equipment is satisfactory for this purpose.

(*b*) The oil bath should be provided with some means for circulating the oil, so that the temperature is substantially uniform around the test specimens, and with a thermometer or thermocouple for measuring the temperature as near the point of test as practicable.

Procedure

39. (*a*) The test material shall be subjected to the test temperature, before voltage is applied, for a period in minutes equal to hall the thickness of the specimen in mils, except molded materials, which shall be heated for 30 min.

(*b*) The tests shall cover the operating range of temperature to which the test material is to be subjected. Where this range is considerable, tests should be made at not less than four points, so that a curve of dielectric strength (volts per mil) against temperature may be plotted. These points should include the maximum and minimum operating temperatures. The number of tests at each temperature shall be as specified in Sections 10 and 31.

APPENDIX

Multiple Form of Tape Tester for Insulating Tapes:

Figure A1 shows the multiple electrode form of tape tester.[1] In this type, a strip of tape is held under pressure between rubber washers encircling the electrodes.

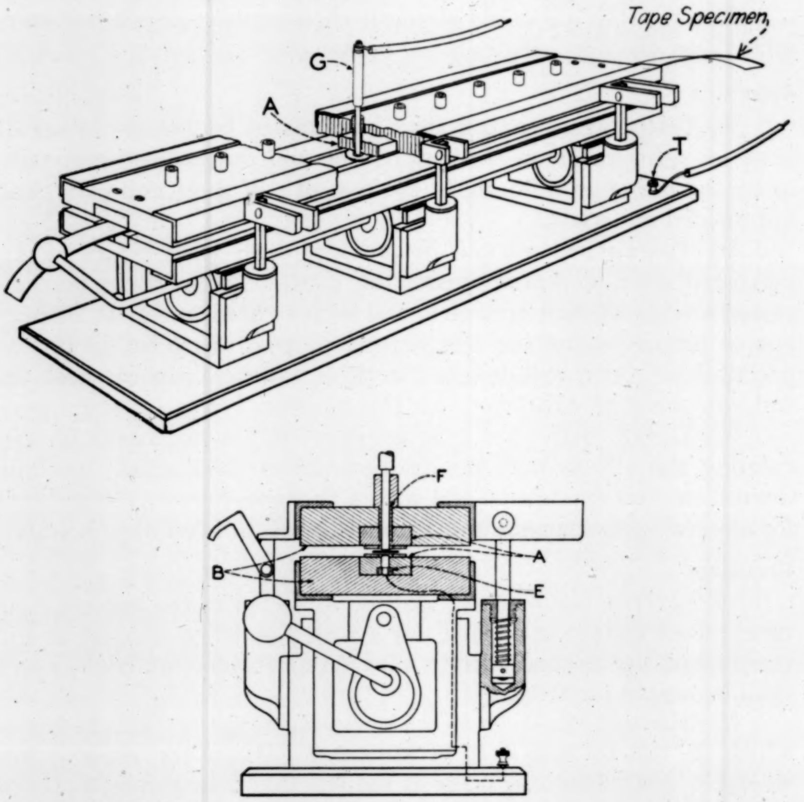


FIG. A1.—Multiple Electrode Tester for Dielectric Strength Test on Insulating Tape.

The washers, having center holes not smaller than $\frac{3}{8}$ in. in diameter, are cemented to two insulating blocks, *A*, which in turn are fastened to two rigid main blocks, *B*. Upper block, *B*, is hinged along one side and fitted with catches along the other to lock the two blocks together. A handle, operating cams through a common shaft, forces lower block, *B*, upward against upper block, *B*, the latter restrained by a set of springs along each side.

---

[1] A detailed drawing of the tape tester may be obtained from Mr. E. J. Rutan, Secretary of Committee D-9 on Electrical Insulating Materials, New York Edison Co., 92 Vandam St., New York City.

NOTE.—Satisfactory washers 1 in. square or 1⅛ in. in diameter have been made of sheet rubber about 0.10 in. in thickness. The "hardness" of the rubber was such that when 10 washers were stacked, a weight of 15 lb. compressed the stack about 10 per cent of its original height.

There are ten lower electrodes which are fixed to a common bus bar, *E*. The upper electrode, *G*, is movable and may be inserted into any of the bushed holes, *F*, which serve to align the upper electrode with the corresponding lower electrode. Voltage is applied between the upper and lower electrodes by direct connection to the upper electrode and by connection to the common bus bar through terminal, *T*. The electrodes are cylindrical brass rods ¼ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.). The weight of the upper electrode is 0.1 lb. (45.4 g.).

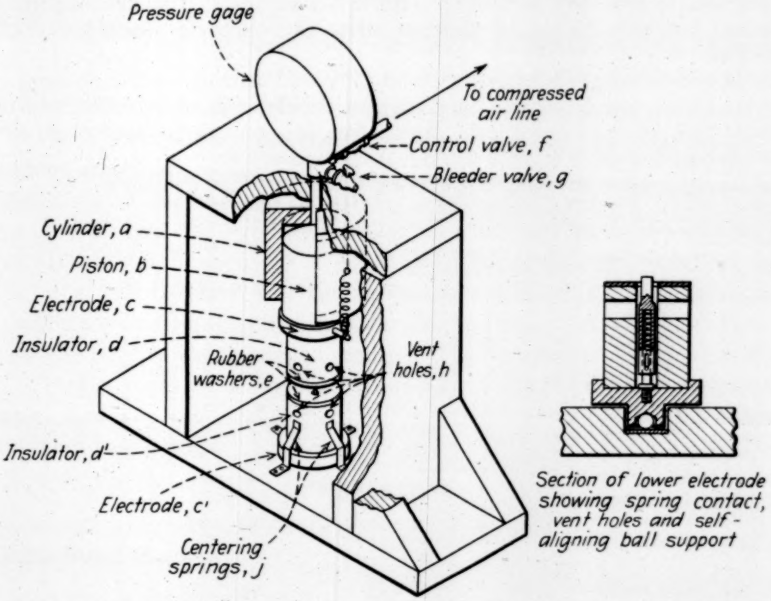

Pressure gage
To compressed air line
Control valve, f
Bleeder valve, g
Cylinder, a
Piston, b
Electrode, c
Insulator, d
Rubber washers, e
Vent holes, h
Insulator, d'
Electrode, c'
Centering springs, j
Section of lower electrode showing spring contact, vent holes and self-aligning ball support

FIG. A2.—Single-Shot Tester for Dielectric Strength Test on Insulating Tape.

After the tape is secured in position, the test is made by moving the upper electrode successively from hole to hole until the specified number of punctures have been obtained.

As carbon is formed during tests, the successful operation of the device depends upon keeping the parts clean. When cleaning the electrodes, care should be taken not to change their form. The rubber washers may require replacement from time to time.

Single-Shot Tester for Insulating Tapes:

In the single-shot tester illustrated in Fig. A2 the tape is also held under pressure between rubber washers while the voltage is applied, but in this device pressure is supplied by compressed air operating on a piston, b, in a cylinder, a. The piston is connected to the upper electrode, c. The lower electrode, c', is mounted on the insulated base. The electrodes terminate in $\frac{1}{4}$-in. brass rods having flat ends with edges rounded to a radius of $\frac{1}{32}$ in. These electrode rods move against light springs. This insures a positive contact between electrode and tape. The electrode rods are surrounded by insulating blocks, d and d', having vent holes, h, for the dissipation of the gases generated by breakdown. These insulating blocks are faced with soft rubber washers, e, which can be detached and replaced as necessary.

The lower electrode assembly is lined up with the upper electrode assembly by centering springs, j, the position of which is adjustable. This lower assembly is also free to rock very slightly on a single ball support. This insures perfect contact and equalization of pressure when the electrode assemblies come together.

The upper electrode assembly is normally held clear of the lower assembly by two small springs so that tape may be readily inserted or withdrawn or moved to a new position of test. The piston, b, is smooth, without rings, and permits just enough leakage of air so that the pressure may be quickly adjusted and readily held at any desired value below the maximum available.

TENTATIVE METHODS OF TESTING ELECTRICAL INSULATING MATERIALS FOR RESISTANCE TO IMPACT[1]

A.S.T.M. Designation: D 256 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1926; REVISED, 1928, 1932, 1934.[2]

Scope

1. (*a*) These methods are intended to determine the relative toughness of electrical insulating materials as indicated by the energy used in breaking a standard test specimen in one blow.

(*b*) This type of impact test is made by machines of the pendulum type of which there are two kinds, the Charpy and the Izod, which differ only in the method of holding and striking the specimen. In the Charpy test the specimen is held as a simple beam (usually horizontal) and is broken by a blow delivered midway between the supports. In the Izod test the specimen is held as a cantilever beam (usually vertical) and is broken by a blow delivered at a fixed distance from the edge of the specimen clamp. The Charpy test may be made on either a plain or a notched specimen as required by the characteristics of the material tested. The Izod test requires a notched specimen in all cases.

APPARATUS

Simple Beam Method (Charpy Test)

Simple Beam Machine

2. (*a*) The machine used in the simple beam method shall be of the pendulum type as shown in Fig. 1, of rigid construction and accurate to within 0.01 ft-lb. for values of impact strength less than 1 ft-lb. and to within 1 per cent for higher values of impact strength. Accurate correction shall be made for friction and windage losses.

(*b*) The dimensions of the machine shall be such that the center of percussion of the striker (Note) is at the point of impact, that is, the center of the striking edge.

NOTE.—The distance from the axis of support to the center of percussion, l, may be determined experimentally from the period of oscillation of the pendulum through a small angle by means of the expression $l = 0.81 P^2$, where P is the time in seconds of a complete swing (to and fro).

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

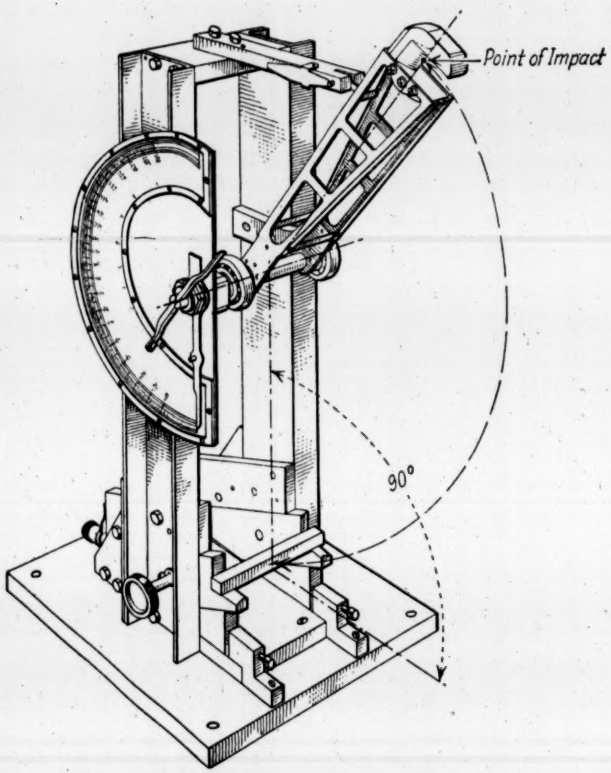

Point of Impact
90°

FIG. 1.—Simple Beam (Charpy) Impact Machine.

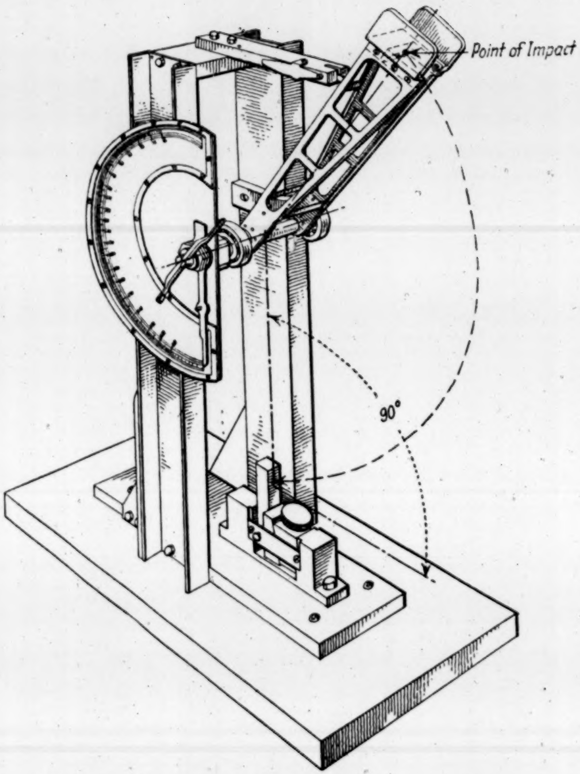

Point of Impact
90°

FIG. 2.—Cantilever Beam (Izod) Impact Machine.

(*c*) The pendulum shall be released from such a position that the linear velocity of the center of the striking edge (center of percussion) at the instant of impact shall be approximately 11 ft. per second, which is that corresponding to an initial elevation of this point of 2 ft.

(*d*) The striking edge of the pendulum shall be tapered to have an included angle of 45 deg. and shall be rounded to a radius of 0.125 in. (3.175 mm.). It shall be so aligned that in the case of rectangular specimens it will make contact across the full width of the specimen.

(*e*) The test specimen shall be supported against two rigid blocks in such a position that its center of gravity shall lie on a tangent to the arc of travel of the center of percussion of the pendulum drawn at the position of impact. The edges of the blocks shall be rounded to a radius of 0.125 in. (3.175 mm.) and the points of support shall be 4 in. (10.16 cm.) apart.

(*f*) Means shall be provided for determining the impact strength. The impact strength shall be taken as the energy absorbed in breaking the specimen, and is equal to the difference between the energy in the pendulum blow and the energy remaining in the pendulum after breaking the specimen.

Cantilever Beam Method (Izod Test)

Cantilever Beam Machine

3. (*a*) The machine used for the cantilever-beam method shall be of the pendulum type as shown in Fig. 2, of rigid construction and accurate to within 0.01 ft-lb. for values of impact strength less than 1 ft-lb. and to within 1 per cent for higher values of impact strength. Accurate correction shall be made for friction and windage losses.

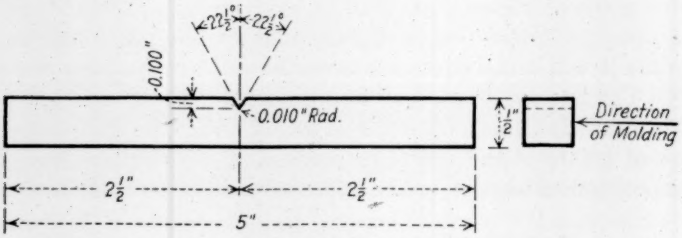
(*b*) The dimensions of the machine shall be such that the center of percussion of the striker is at the striking edge.

(*c*) The pendulum shall be released from such a position that the linear velocity of the striking edge at the instant of impact shall be approximately 11 ft. per second, which is that corresponding to an initial elevation of the striking edge of 2 ft.

(*d*) The striking edge of the pendulum shall be an unrounded edge formed, in the position of impact, by the intersection of a plane inclined away from the specimen at an angle of 5 deg. from the vertical with another plane perpendicular to the specimen, and shall be so aligned as to make contact across the full width of the specimen. In the striking position the striking edge shall be 0.866 in. from the edge of the specimen clamp.

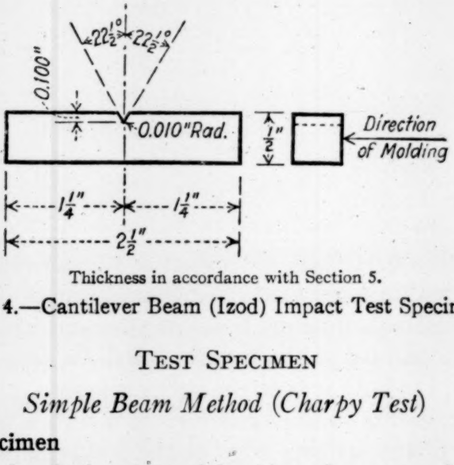
(*e*) Means shall be provided for clamping the specimen rigidly in position with the edges of the supporting surfaces at 90-deg. angles.

(*f*) Means shall be provided for determining the impact strength. The impact strength shall be taken as the energy absorbed in breaking the specimen, and is equal to the difference between the energy in the pendulum blow and the energy remaining in the pendulum after breaking the specimen.



Thickness in accordance with Section 4.

FIG. 3.—Simple Beam (Charpy) Impact Test Specimen.



Thickness in accordance with Section 5.

FIG. 4.—Cantilever Beam (Izod) Impact Test Specimen.

TEST SPECIMEN

Simple Beam Method (Charpy Test)

Charpy Test Specimen

4. (*a*) For insulating materials other than ceramic materials the specimen shall conform to the dimensions shown in Fig. 3. The notch may be milled, filed, or molded provided the bottom of the resulting notch is smooth, straight and free from scratches. For molded material the thickness of the molded specimen, that is, the dimension parallel to the application of the molding pressure and lengthwise of the notch, may be any thickness of ½ in. or less agreed upon as representative of the cross-section in which the particular material is to be used. For sheet material the thickness shall be the thickness of the sheet except that it shall not exceed ½ in. When the individual specimen is less than ½ in. in thickness, the test piece shall be a com-

posite specimen consisting of a number of individual thin specimens aggregating as nearly as possible ½ in. in thickness and all being accurately aligned with each other when tested. Specimens of molded insulating material shall be conditioned before testing by drying in an oven at 50 C. ± 5 C. (122 F. ± 9 F.) for 48 hr., followed by cooling to room temperature in a desiccator. Tests shall be made at room temperature.

(*b*) For ceramic materials the specimen shall be an unnotched cylinder 6 in. (15.2 cm.) in length. The diameter shall be 0.5 in. (1.27 cm.), 0.75 in. (1.91 cm.), or 1.125 in. (2.86 cm.), whichever value is comparable to that of the finished product.

NOTE.—The type of mold used to produce test specimens has an effect on the results obtained. Cooperating laboratories should, therefore, standardize mold and testing procedure to obtain concordant results.

Cantilever-Beam Method (Izod Test)

Izod Test Specimen

5. For insulating materials other than ceramic materials the specimen shall conform to the dimensions shown in Fig. 4. The notch may be milled, filed or molded provided the bottom of the notch is smooth, straight and free from scratches. For molded material the thickness of the molded specimen, that is, the dimension parallel to the application of the molding pressure and lengthwise of the notch, may be any thickness less than ½ in. agreed upon as representative of the cross-section in which the particular material is to be used. For sheet material the thickness shall be the thickness of the sheet except that it shall not exceed ½ in. Sheet material when thicker than ½ in. may be tested either edgewise or flatwise as specified (Note 1) and when tested flatwise the notch shall be made in the original surface. When the individual specimen is less than ½ in. in thickness, the test piece shall be a composite specimen consisting of a number of individual thin specimens aggregating as nearly as possible ½ in. in thickness and all being accurately aligned with each other when tested. Specimens of molded insulating material shall be conditioned before testing by drying in an oven at 50 C. ± 5 C. (122 F. ± 9 F.) for 48 hr., followed by cooling to room temperature in a desiccator. Tests shall be made at room temperature.

NOTE 1.—In referring to the cutting of the specimens of laminated sheet materials and the application of the load, the following definitions apply:

Flatwise.—Load applied to the flat side of the original sheet or plate.

Edgewise.—Load applied to the edge of the original sheet or plate.

NOTE 2.—The type of mold used to produce test specimens has an effect on the results obtained. Cooperating laboratories should, therefore, standardize mold and testing procedure to obtain concordant results.

METHOD

Simple Beam Method (Charpy Test)

Charpy Test Procedure

6. (*a*) Five individual determinations of impact strength shall be made.

(*b*) The test specimen shall be supported against the steel blocks so that the blow will be struck at the center of the specimen and on the side opposite the notch for notched specimens.

(*c*) When a composite specimen is used the individual members shall be closely in contact and accurately aligned with each other. It is recommended that a jig be used to insure alignment of notches.

Cantilever Beam Method (Izod Test)

Izod Test Procedure

7. (*a*) Five individual determinations of impact strength shall be made.

(*b*) The test specimen shall be rigidly clamped with the center line of the notch on the level of the top of the clamping surface (Note) and the blow shall be struck on the notched side.

(*c*) When a composite specimen is used the individual members shall be held closely in contact and accurately aligned with each other when clamped (Note).

NOTE.—It is recommended that a template be used to locate the specimen in the jaws as specified.

REPORT

Report

9. The report of the test shall include the following:

(*a*) A statement indicating the type of test, the specimen used and for sheet materials, the direction of testing;

(*b*) For insulating materials other than ceramic materials, the value of energy absorbed in each individual test expressed in foot-pounds per inch of notch, determined by dividing the energy in foot-pounds absorbed in the individual test by the actual dimension in inches along the notch of the specimen broken in each test, whether a single or a composite specimen was used; and

(*c*) The average of the values given in Paragraph (*b*) and the thickness or diameter of the specimen and the number broken in each individual test.

TENTATIVE METHODS OF TESTING MOLDING POWDERS USED IN MANUFACTURING MOLDED ELECTRICAL INSULATORS[1]

A.S.T.M. Designation: D 392 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. These methods cover tests for certain physical properties of molding powders, used for the manufacture of electrical insulators and other plastic molded parts. These powders consist of an organic binder of either the thermo-plastic or heat-reactive type and organic or inorganic fillers or mixtures of such fillers.

SAMPLING

Purpose

2. This sampling procedure is intended for obtaining a representative sample of a batch or shipment of molding compound from the manufacturer's original packages.

Procedure

3. (*a*) If the complete shipment is indicated by the manufacturer's marking to consist of only one batch or "run" of material, the number of packages selected for sampling shall be not less than 10 per cent of the packages in the batch, and in any case, not less than 3 packages. The packages selected for sampling may be chosen at random, or in case the manufacturer has marked the packages to indicate the order in which they were filled from his batch, the selection may be made with reference to this order of filling, if desired by the purchaser. If the shipment consists of more than one batch or "run" of material, each batch shall be sampled separately to produce one composite blended sample for examination for each batch in the shipment.

(*b*) The packages selected shall be opened carefully, making sure that no contamination enters them from scale, paint, shattered heads, torn liners, or other causes. From each standard size drum sampled, an equal number of scoopsful of material shall be taken from a point about 3 in. below the surface. From smaller packages the sample shall be taken from a point 1 in. below the surface. The material shall be transferred to a clean, dry, sheet metal or glass container, capable of being tightly closed. The gross quantity of sample taken shall be approximately twice that estimated to be required for the tests which are to be made. This allowance is made in order to permit repeat tests without re-sampling. The composite sample shall be blended thoroughly before using for the desired tests.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

NOTE.—Drums of molding powder in transit, and frequently during packing at the manufacturers' plant, become shaken down and frequently are so densely compacted that only a few ounces of material would fall out if the container were inverted. The few coarse particles not bound in the mass show plainly on the top surface, giving the impression that the fines have sunk and the coarse particles risen. A check-up by sieve analysis of samples taken just under the surface, and throughout the drum, ordinarily fails to disclose segregation.

PARTICLE SIZE DETERMINATION OR SIEVE ANALYSIS

Scope

4. Two procedures, Methods *A* and *B*, are given for determining the size distribution of the particles in the molding powder being examined. Method *A* is a complete sieve analysis and Method *B* a shorter check method by which the relative quantities of coarse and fine particles in a powder may be readily determined.

Method A

General Description

5. The test is made by distributing the powder on a series of sieves of different mesh openings and determining the weight of material retained by each sieve after thorough shaking.

Apparatus

6. (*a*) *Sieves.*—The sieves used shall be of the U. S. Standard Sieve Series, half-height, 8 in. in diameter, conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[1] The following sieves together with a cover and bottom pan will be required:

U. S. STANDARD SIEVE SERIES NUMBER	SIEVE OPENING, MICRONS
No. 12	1680
No. 20	840
No. 40	420
No. 70	210
No. 140	105

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

(*b*) *Machine Sieving Device.*—There will also be required a mechanical sieve-shaking device and an automatic time switch or equivalent device.

(*c*) *Balance.*—A sensitive laboratory balance of 500-g. capacity, sensitive to 0.1 g., shall be used for weighing the sample and the residue retained on the sieves. Other accessories required are suitable brushes for cleaning the sieves, paper for collecting samples and any other items of equipment ordinarily used in making a sieve analysis.

Method

7. The sieves specified in Section 6 shall be stacked together in the order of size opening with the coarsest on top and the pan on the bottom. A 100-g. sample (Note 1) shall be accurately weighed and transferred to the top sieve of the stack which shall then be covered. The stack of sieves shall then be placed in the machine sieving device and shaken for 10 min., ± 15 sec. After shaking, the stack of sieves shall then be carefully separated, beginning at the top, and the amount of material retained on each sieve and in the bottom pan shall be determined by weighing. In transferring the powder from the sieve to the weighing scale, care shall be taken to brush clean from the back of the sieve all adhering particles. The cumulative percentage of original sample retained on each sieve and in the bottom pan shall be calculated (Note 2).

Report

8. The report shall include the following:

(*a*) the actual percentage of material retained on each sieve, and

(*b*) the cumulative total percentage of material retained on each sieve and in the bottom pan.

Method B

General Description

9. The test is made by distributing the powder on one coarse and one fine sieve and determining the weight of the material retained on each sieve after thorough shaking.

Apparatus

10. (*a*) *Sieves.*—The sieves used shall be of the U. S. Standard Sieve Series conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[1] The sieves required are the No. 12 (1680-micron) and No. 140 (105-micron) together with a cover and bottom pan.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1244.

(*b*) *Mechanical Sieving Device.*—There will also be required a mechanical sieve-shaking device and an automatic time switch or equivalent device.

(*c*) *Balance.*—A sensitive laboratory balance of 500-g. capacity, sensitive to 0.1 g., shall be used for weighing the sample and the residue retained on the sieves. Other accessories required are suitable brushes for cleaning the sieves, paper for collecting samples and any other items of equipment ordinarily used in making a sieve analysis.

Method

11. The No. 12 sieve shall be stacked on the No. 140 sieve with the pan underneath. A 100-g. sample (Note 1) shall be accurately weighed and transferred to the No. 12 sieve, which shall then be covered. The stack of sieves shall then be placed in the machine sieving device and shaken for 10 min., ±15 sec. After shaking, the sieves shall be carefully separated and the amount of material retained on each sieve and in the bottom pan shall be determined by weighing. In transferring the powder from the sieve to the weighing scale, care shall be taken to brush clean from the back of the sieve all adhering particles. Weigh and record the weights from each sieve and the pan separately and calculate the percentages retained on the No. 12 and through the No. 140 sieve (Notes 2 and 3).

Report

12. The report shall include the two percentages of coarse and fine material, respectively, as calculated in Section 11. Note should be made of any unusually large particles found on the No. 12 sieve.

NOTE 1.—If necessary this test may be made on a sample of any size from 50 to 200 g. The weight of sample used shall be stated in the report.

NOTE 2.—Ordinarily there is a small loss of dust indicated by the cumulative total of actual weight being less than 100 per cent. If this loss is not over 2 per cent, the amount reported through the finest sieve shall be increased until the total of all portions of the sample equal 100 per cent. If the cumulative total of actual weight is less than 98 per cent, the weights and operations shall be carefully checked and the work repeated, if necessary.

NOTE 3.—The consumer will probably be interested in particle size only along lines rather definitely restricted as follows:

First, particles substantially larger than normal sieve size, such as might be present due to broken screen wire in the manufacturers' plant, would tend to stop up tablet machine hoppers, give irregular tablet weights, and rough or streaked molded surfaces. Ordinarily a single coarse sieve provides a satisfactory check, that is, the No. 12 given in Method B.

Second, an excess of very fine particles would tend to cause excessive dusting, high bulk factor and irregular tablet weights due to failure to pour freely. (The amount may be determined by the use of the No. 140 sieve in Method B.) A certain amount of the finest particle sizes is usually desirable for improving finish and reducing bulk factor. Excessive fines may be indicated better by bulk factor and pourability than by sieve test.

APPARENT DENSITY

Purpose

13. The apparent density test is intended to determine the fluffiness or bulk of molding powder in loose condition by weighing and measuring a standard quantity of the loose powder.

Apparatus

14. The apparatus shall consist of the following:

(*a*) *Measuring Cup.*—A cylindrical measuring cup of 100-cc. capacity having a diameter equal to half the height. Such a cylinder would be 1.572 in. (3.99 cm.) in inside diameter by 3.144 in. (7.98 cm.) in inside height.

(*b*) *Funnel.*—A funnel mounted as shown in Fig. 1.

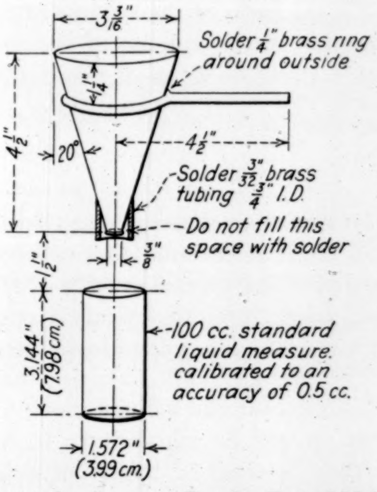

$3\frac{3}{16}$"
Solder $\frac{1}{4}$" brass ring around outside
$1\frac{1}{4}$"
$4\frac{1}{2}$"
20°
$4\frac{1}{2}$"
Solder $\frac{3}{32}$" brass tubing $\frac{3}{4}$" I.D.
Do not fill this space with solder
$\frac{3}{8}$"
$1\frac{1}{2}$"
3.144" (7.98 cm.)
100 cc. standard liquid measure. calibrated to an accuracy of 0.5 cc.
1.572" (3.99 cm.)

FIG. 1.—Apparatus for Apparent Density Test of Molding Powders.

Procedure

15. A well-mixed 120-cc. sample shall be selected from the general samples of powder. With the apparatus assembled as shown in Fig. 1, the small end of the funnel shall be closed with the hand or with a suitable flat strip of material and the 120-cc. sample poured into the funnel. The bottom of the funnel shall then be opened quickly and the material allowed to flow freely into the cup. If caking occurs in the funnel the powder may be loosened with a small glass rod. After all the material has passed through the funnel, the excess powder on the top of the cup shall be scraped off with a straight edge. The material in the cup shall then be accurately weighed to the nearest 0.1 g. The weight, in grams, of 1 cc. of powder shall then be

calculated (Note 1). Three determinations of the apparent density shall be made on each sample and the results averaged (Note 2).

Report

16. The report shall include each value of apparent density and the average apparent density.

NOTE 1.—To convert grams per cubic centimeter to ounces per cubic inch multiply by 0.576. To convert grams per cubic centimeter to grams per cubic inch multiply by 16.38.

NOTE 2.—Apparent density figures are not comparable except on compounds having the same specific gravity after molding.

BULK FACTOR

Definition

17. Bulk factor is the ratio of the volume of any given quantity of loose molding powder to the volume of the same material after molding. By suitable transformation of this ratio, it will be found that the bulk factor is also equal to the ratio of the specific gravity after molding to the apparent density of the loose molding powder.

Procedure

18. (*a*) *Apparent Density.*—The apparent density of the molding powder shall be determined as described in Sections 13 to 16.

(*b*) *Specific Gravity.*—The specific gravity of the molding powder (after molding) shall be determined by any accurate method; such as, weighing two or more samples molded from the molding powder in air and in water. The average result obtained shall be used. If the shape of the piece is such that the volume may be readily calculated from the dimensions, it will be satisfactory to use this calculated volume in place of that determined by loss of weight in water.

(*c*) *Calculation.*—The bulk factor shall be calculated by dividing the average specific gravity of the molded piece by the average apparent density (in grams per cubic centimeter) of the molding powder.

Report

19. The report shall include the average apparent density and specific gravity and the bulk factor (Note) calculated from them.

NOTE.—The bulk factor test is comparable as between all grades of molding compound, regardless of the specific gravity after molding.

TENTATIVE METHODS OF TESTING UNTREATED PAPER USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 202 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1924; Revised, 1925, 1926, 1927, 1928, 1929, 1930, 1932, 1933, 1934.[2]

1. These methods are intended to apply to untreated paper to be used as an electrical insulator or as a constituent of a composite material used for electrical insulating purposes. **Scope.**

SAMPLING

2. (*a*) From shipments consisting of rolls, a sample of at least 1 sq. yd. in area, cut across the entire width of the roll, shall be taken from every tenth roll in the shipment. From other shipments such as sheets or pads of tape, samples of equivalent area shall be taken in such a manner as to be equally representative of the shipment. In no case shall less than three samples be taken. **Sampling.**

Note.—It is recommended that several turns of paper from each roll sampled be torn off and discarded before the samples are taken.

(*b*) The tests for physical properties shall be made upon each sample.

(*c*) The tests for acidity, moisture content, size,[3] ash and for identification of fibers[3] shall be made in duplicate upon portions taken from a composite sample. This composite sample shall be made up of a sufficient number of small pieces, each of approximately 6.5 sq.cm. (1 sq. in.) in area taken in nearly equal amounts from each of the samples taken in accordance with Paragraph (*a*).

(*d*) The required number of samples shall be taken at equal intervals across the sheet, the two end samples being taken at the edges of the sheet after removing any damaged paper. When it is not possible to secure the required number of specimens in this manner in going once across the sheet, the selection across the sheet shall be repeated as many times as necessary until the required number of specimens is secured.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

[3] The tests for size and identification of fibers do not appear in these methods but will be included as soon as the tests are developed by the committee.

CONDITIONING SAMPLES

Conditioning. 3. Samples shall be conditioned in air maintained at a relative humidity between 60 and 65 per cent as measured with a sling psychrometer or its equivalent. The temperature of the air shall be maintained as constant as possible at some temperature between the limits of 20 and 30° C. (68 and 86° F.). The samples should remain in the conditioned air for not less than 4 hours prior to the tests and should be supported so as to allow a free circulation around each sample. The following physical tests shall be made in the conditioned air: tensile breaking strength, tearing strength, bursting strength, folding endurance, air resistance, dielectric strength and thickness.

MOISTURE CONTENT

Apparatus. 4. A weighing bottle, evaporating dish, thermometer, constant-temperature oven, chemical balance and desiccator are necessary for the test. The weighing bottle should be of convenient size, about 65 mm. (2.56 in.) in height and 45 mm. (1.77 in.) in diameter with a wide mouth provided with a ground-glass stopper. The chemical balance should be sensitive to 0.1 mg.

Specimen. 5. The moisture content figure is used to calculate the percentage of acidity, size, and ash of the paper to the bone-dry basis. It shall be determined on 2 to 5-g. samples selected in accordance with Section 2 (*c*).

If the moisture content of the paper as received at the purchaser's works is desired or at any other stated time, it shall be made on the sample taken at the definitely stated time by cutting small pieces of approximately 6.5 sq. cm. (1 sq. in.) in area from the required number of rolls or pads of tape in accordance with Section 2 (*a*) and immediately placed into an air-tight container.

NOTE.—Since paper adjusts itself, as regards moisture content, to the humidity of the surrounding atmosphere in a very short time (2 or 3 minutes), special care must be exercised to transfer rapidly the sample from the roll or bundle to the container and from the container to the weighing bottle.

Procedure. 6. The sample before drying shall be weighed in the tared bottle with the stopper in place. The bottle shall then be placed in the oven at 100 to 105° C. (212 to 221° F.), the stopper removed and laid alongside of the bottle and the contents transferred to the drying dish. After one hour, while still in the oven, the sample shall be replaced in the weighing bottle, and the bottle stoppered and transferred to the desiccator. The stopper should be removed while the bottle cools. When the specimen and the bottle have cooled to room temperature, the stopper shall be replaced and the bottle with its contents weighed. This process shall be repeated at intervals of one hour until the difference in weight between two successive weighings is not more than 0.2 per cent of the weight of the specimen.

NOTE.—The weighing bottle or sample should not be touched with the fingers during this test.

Report. 7. The moisture content shall be expressed:

(*a*) as a percentage of the weight of the dry sample, and

(*b*) as a percentage of the weight of the undried sample.

THICKNESS

Apparatus. 8. The thickness shall be determined in accordance with the Tentative Methods of Test for Thickness of Solid Electrical Insulation (A.S.T.M. Designation: D 374 - 34 T) of the American Society for Testing Materials.[1]

Specimens. 9. Specimens shall consist of the original samples obtained in accordance with Section 2 (*a*).

Number of Measurements. 10. At least five measurements of the thickness shall be taken at regular intervals across the entire width of each specimen.

Report. 11. The average, maximum, and minimum thicknesses obtained on each specimen shall be reported.

TENSILE BREAKING STRENGTH

Apparatus. 12. (*a*) A testing machine of the dead-weight pendulum type suitably designed for testing paper shall be used. The machine shall preferably be power driven.

(*b*) The capacity of the machine shall not exceed 113 kg. (250 lb.).

(*c*) The machine shall be graduated to read 1 lb. or 1 kg. or less per scale division for testing paper breaking at 22.7 kg. (50 lb.) or over, and to 0.5 lb. or 0.5 kg. or less for testing paper breaking under 22.7 kg. (50 lb.).

Specimens. 13. From each of the samples selected in accordance with Section 2 (*a*), specimens shall be cut at least ten in the machine direction and if practicable, ten in the cross-machine direction. The specimens shall not exceed 2.54 cm. (1 in.) in width and shall be 25.4 cm. (10 in.) in length with clean-cut edges.

Procedure. 14. (*a*) The ratio of the clearance distance between jaws to the width of the specimen shall not be less than 5 to 1 nor more than 10 to 1.

(*b*) The rate of travel of the movable jaw shall be constant. It shall preferably be 30.5 cm. (12 in.) per minute, but it may be within the limits of 28 cm. (11 in.) and 33 cm. (13 in.) per minute provided it is constant.

---

[1] See p. 1069.

(*c*) All readings obtained when the paper breaks at or in the jaws shall be rejected.

Report. 15. (*a*) The results of the machine-direction specimens and the cross-machine-direction specimens shall be reported separately.

(*b*) The results shall be reported in kilograms or pounds together with the width of the specimen in centimeters or inches and also the average thickness.

(*c*) The maximum, minimum, and average breaking load shall be reported for the machine direction and the cross-machine direction.

TEARING STRENGTH

Apparatus. 16. The testing machine shall be of the pendulum impulse type so designed as to produce a tear approximately 4.2 cm. (1.66 in.) long. The knife mounted on the machine to cut the slit for the tear shall be maintained sharp.

Specimen. 17. The specimens shall be taken from the original samples obtained in accordance with Section 2 (*a*) and shall be cut 6.3 cm. (2.5 in.) in width and at least 6.3 cm. (2.5 in.) in length. Enough specimens shall be cut so that at least five readings in the machine direction and five readings in the cross-direction, if possible, can be obtained for each original sample.

Method. 18. Enough paper shall be torn so that the readings on the machine shall be not less than 10 nor more than 20 g., unless one paper alone yields a reading greater than 20 g., in which case only one paper shall be torn at one time. The specimens shall be so arranged that an equal number of tears originating from opposite edges of the specimens will be produced. Readings obtained when a tear deviates more than 6.3 mm. (0.25 in.) from a straight line, shall be rejected. The readings obtained shall be multiplied by the instrument constant corresponding to the number of sheets torn.

Report. 19. (*a*) The tearing strengths obtained on the machine-direction specimens and on the cross-direction specimens shall be reported separately in grams.

(*b*) The average, the maximum, and the minimum tearing strengths shall be reported for the machine-direction specimens. If possible, similar results shall be reported for the cross-direction specimens.

BURSTING STRENGTH

Apparatus. 20. The testing machine shall have a circular flexible diaphragm 6.44 sq. cm. (1 sq. in.) in area. The pressure chamber shall be filled with glycerin or other suitable pressure medium and shall contain no air spaces. The test specimen shall be held in position over the diaphragm in a clamp having a circular hole approximately 6.44 sq. cm. (1 sq. in.) in area so that the diaphragm will force the paper into the hole when pressure is applied under the diaphragm. The pressure exerted on the diaphragm shall be indicated on a dial, graduated to at least 0.23 kg. (0.5 lb.) for papers giving bursting strengths 18 kg. (40 lb.) or under. A dial graduated 0.45 kg. (1 lb.) may be used in testing papers which give higher bursting strengths. The machine may be either hand-operated or power-driven, the latter being preferable.

Specimen. 21. If practicable, the specimen shall be so cut from the stock as to permit ten bursting tests on a line across the sheet or roll.

Procedure. 22. Ten bursts shall be made, five with one side of the paper uppermost and five with the other side uppermost. The testing machine shall be driven at a uniform speed of 120 r.p.m. until the specimen bursts.

Report. 23. The report shall include the average, the maximum, and the minimum results obtained.

FOLDING ENDURANCE

Apparatus. 24. The testing instrument shall be of the adjustable-tension, vertical test-strip position type, Fig. 1, and shall consist of the following:

(*a*) A loading clamp and an oscillating clamp mounted in the same plane. The upper or loading clamp shall have a suitable clamping device, constrained to a vertical movement without rotation. A spring shall be attached to the loading clamp that will give different tensions from 0 to 1.5 kg. dependent upon the displacement. The deflection of the spring when loaded shall not be less than 17 mm. per kg.

(*b*) The lower or oscillating clamp shall be provided with two jaws, each of which terminate in a cylindrical edge near the axis of rotation. The two edges shall be 0.76 mm. ± 0.03 mm. (0.031 in. ± 0.001 in.) in diameter, and not less than 19 mm. (0.748 in.) in length. They shall be parallel to each other and to the axis of rotation. The jaws shall be smooth over all surfaces which come in contact with the paper during the folding cycle. The rotary oscillating movement of the folding clamp shall be such as to fold the paper through an angle of 135 deg. ± 5 deg., to both right and left of the position of zero fold. The folding speed shall be between 140 and 210 double folds per minute.

(*c*) The width of the slot (distance separating folding surfaces) in the oscillating clamp shall be greater than the uncompressed thickness of the paper being tested but shall not exceed it more than 0.25 mm. (0.01 in.).

(*d*) A power-driven device for imparting a rotary oscillating motion of constant period to the folding clamp.

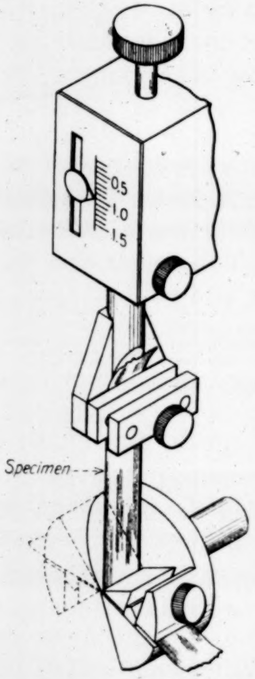


FIG. 1.—Sketch Showing Loading and Oscillating Clamps of Folding Endurance Tester, with Paper Specimen in Testing Position.

(*e*) A device for registering the number of double folds required to sever the specimen.

Specimens. 25. The specimens shall be taken from the original samples obtained in accordance with Section 2 (*a*) and shall be cut 15 mm. (0.59 in.) in width and with a length such as to insure a firm grip in the jaws without buckling. Not less than 10 strips cut with the machine direction parallel with the strip length and, if practicable, 10 strips cut in the cross-machine direction shall be tested. The specimens shall be conditioned in accordance with Section 3.

Procedure.

26. (*a*) The oscillating clamp shall be placed in the position of zero fold. A 1.0-kg. weight shall be placed on top of the plunger and the plunger clamped in position when depressed under this load. The specimen shall then be clamped firmly and squarely in the jaws with the surface of the specimen lying wholly within one plane and not touching the jaw mounting-plate. The specimen shall be handled by the ends and not touched with the hands in the region which is to be folded. The specified tension shall then be applied to the test strip by releasing the plunger. If the reading of the load indicator has changed, it shall be reset by means of the adjusting screw to agree with the reading obtained when the weight was applied. The strip shall be folded at a uniform rate until it is severed at the crease. The number of double folds required to sever the specimen shall be recorded.

(*b*) If a tension of 1.0 kg. is too great or too little to afford practical test results, a greater or lesser tension than 1.0 kg. may be used.

Calibration.

27. (*a*) All working parts shall be in good condition, well oiled, and in proper adjustment. Particular care shall be given to make certain that the folding edges are free from rust or dirt.

(*b*) The plunger friction shall be measured by determining the additional load required to move the plunger perceptibly when displaced under a load of 1.0 kg. or the load tension used in testing. The additional load required shall not be greater than 25 g.

(*c*) The change in tension due to eccentricity of rotation of folding edges shall be measured as follows: Place a test strip of strong paper, cut in the machine direction, of the proper thickness in the tester in the same manner in which a folding test would be made, and apply a tension of 1.0 kg. or that used in the testing. Rotate the lower jaw slowly throughout the entire folding cycle and measure the maximum change in displacement of the plunger to an accuracy of 0.10 mm. (0.004 in.). The amount of load required to produce the same displacement shall not be greater than 35 g.

Report.

28. The report shall include the number of tests, and the average, the maximum, and the minimum results for both of the principal directions of the paper. The results shall be expressed as M.I.T. double folds at the tension used. Tests run on strips having their length in the machine direction shall be designated as those of "machine direction." In reporting average results, all digits after the first two shall be rounded to zeros.

ABSORPTION

(RISE OF WATER)

Apparatus. 29. A suitable container and support for specimens and scale is shown in Fig. 2.

Specimens. 30. Ten strips 2.5 cm. (1 in.) in width and at least 12.5 cm. (5 in.) in length shall be cut from the samples obtained in accordance with Section 2 (*a*), five being cut parallel with the machine direction of the paper and five being cut parallel with the cross-direction of the paper.

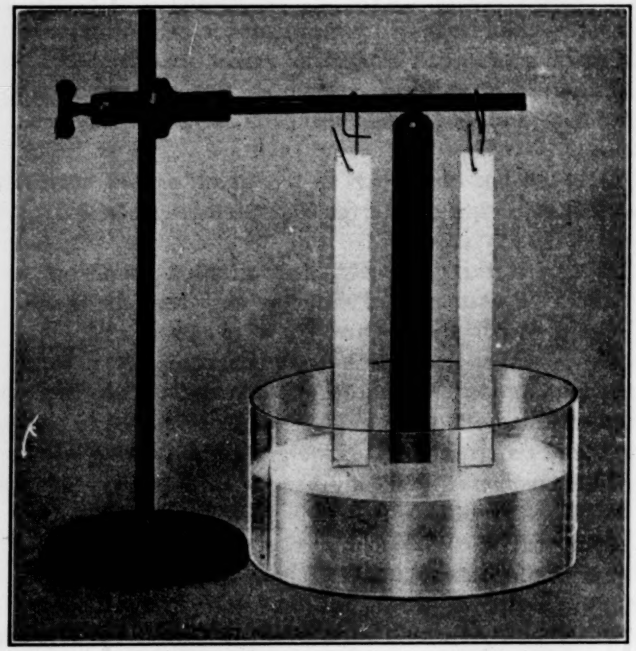


FIG. 2.—Apparatus for Absorption Test.

Procedure. 31. The specimens shall be suspended vertically with one end dipping 3.2 mm. (0.125 in.) in distilled water at room temperature.

After five minutes of suspension, the rise of the water in the paper above the water level shall be noted. The rise may be measured by reading directly from the scale the height of absorption.

Report. 32. The rise of water shall be reported in millimeters to the nearest 3 mm. or in inches to the nearest $\frac{1}{8}$ in.

MIL WEIGHT PER REAM
(APPARENT DENSITY)

Apparatus. 33. A scale, sharp knife, chemical balance and weighing bottle are necessary for the test.

Specimens. 34. Duplicate specimens shall be taken from as widely separated portions as possible from each of the samples obtained in accordance with Section 2 (*a*) and conditioned in accordance with Section 3.

Procedure. 35. (*a*) Each specimen while in the conditioned atmosphere (see Section 3) shall be cut accurately to any convenient size, for example, 232.3 sq. cm. (36 sq. in.) in area, and accurately weighed. Specimens of sufficient size to weigh at least from 3 to 5 g. (0.11 to 0.18 oz.) should be taken. If it is not possible to do the weighing in the conditioned atmosphere, the specimen shall be placed in a weighing bottle and tightly stoppered with a ground glass stopper before being removed from the conditioned atmosphere. The thickness of each specimen shall be determined in accordance with Sections 8 to 11.

(*b*) *Mil Weight per Ream of Any Size.*—The mil (or point) weight in pounds per ream of any size may be calculated from the following formula:

$$W = 0.002205 \frac{mSN}{ta}$$

where m = the weight of the specimen expressed in grams;

t = the average thickness of the specimen expressed in mils (thousandths of an inch);

a = the area of the specimen expressed in square inches;

S = the area of one sheet in the basic ream expressed in square inches;

N = the number of sheets in the ream.

NOTE.—0.002205 is contracted from 0.00220462.

NOTE.—The following formulas may be used to calculate the mil weight in pounds per ream for reams of particular sizes, provided a specimen of exactly 232.3 sq. cm. (36 sq. in.) is used:

Ream of 24 by 36 in., 480 sheets.

$$W = 25.40 \frac{m}{t}$$

where m = the weight of specimen expressed in grams;

t = the average thickness of the specimen in mils (thousandths of an inch).

25.40 is contracted from 25.3972224.

Ream of 24 by 36 in., 500 sheets.

$$W = 26.45 \frac{m}{t}$$

where m and t are the same as above and 26.45 is contracted from 26.45544.

NOTE.—The ream weight may be obtained from the above formulas by omitting the thickness "t".

(*c*) *Weight per Unit Volume.*—The weight in pounds per cubic foot (density) may be calculated from the following formula:

$$D = 3810 \frac{m}{ta}$$

where m = the weight of the specimen expressed in grams.

t = the average thickness of the specimen expressed in mils (thousandths of an inch).

a = the area of the specimen expressed in square inches.

NOTE.—3810 is contracted from 3809.58336.

NOTE.—To convert weight in pounds per cubic foot to mil weight in pounds per ream of 24 by 36 in., 480 sheets, multiply by 0.24; to convert to mil weight in pounds per ream of 24 by 36 in., 500 sheets, multiply by 0.25.

Report. 36. The weight in pounds per cubic foot or the mil weight per ream shall be reported. The size of the ream must be given when the mil weight per ream is reported.

AIR RESISTANCE

Apparatus. 37. (*a*) The instrument shall consist of two aluminum open-top cylinders, one of which is inverted and slides into the other which is fixed. The movable cylinder shall be provided with a circular aperture in the closed end and a flat ring clamp for holding the paper specimen across this aperture.

(*b*) The fixed cylinder shall be 25.4 cm. (10 in.) in height and shall have an external diameter of 8.60 cm. (3.38 in.) and an internal diameter of 8.25 cm. (3.25 in.). Four slender bars, each 18.5 cm. (7.3 in.) long, 3 mm. (0.12 in.) wide and approximately 1.5 mm. (0.06 in.) thick shall be mounted vertically and equi-distantly on the inner surface of the fixed cylinder to act as guide tracks for the movable cylinder. The movable cylinder shall be graduated in units of 50 ml. and shall have a total range of 350 ml. It shall be 25.4 cm. (10 in.) high and shall have an external diameter of 7.62 cm. (3.00 in.) and an internal diameter of 7.35 cm. (2.90 in.). It shall weigh, including the flat ring clamp and the two knurled nuts, 567 g. ± 0.5 g. (20 oz. ± 0.018 oz.). The movable cylinder and the flat ring clamp shall have a concentric circular aperture of 6.44 sq. cm. (1.00 sq. in.) in area. When this aperture is too large for the specimen a similar movable cylinder and flat ring clamp having a concentric circular aperture of 1.61 sq. cm. (0.25 sq. in.) in area shall be used.

NOTE.—Results obtained with apertures of different areas are not directly proportional to the areas of the apertures. The proportionality factor must be determined by experiment.

Specimen. 38. The specimens shall be not less than 3.5 cm. (1.36 in.) nor more than 5.1 cm. (2.0 in.) in width cut from the original samples, taken in accordance with Section 2 (*a*) and shall be as long as the width of the original roll of paper. If the specimens are selected from pads of tape they shall be not less than 2.1 cm. (0.81 in.) nor more than 5.1 cm. (2.0 in.) wide and at least 30 cm. (12 in.) long. There shall be as many specimens as there are original samples.

Procedure. 39. The fixed cylinder shall be placed on a rigid support so that its sides are vertical. A lubricating oil with viscosity of 60 to 70 seconds Saybolt at 37.8° C. (100° F.) shall be placed in it to a depth of 12.7 cm. (5 in.). The specimen (one thickness only) shall be secured tightly under the clamp on the movable cylinder completely covering the aperture. The movable cylinder is then floated on the lubricating oil. The time required for the displacement of a certain amount of air shall be noted with a stop-watch. If possible, the amount of air displaced should be such that the time of displacement is not less than 20 seconds. The apparatus with its content of lubricating oil shall be at the temperature of the conditioning room when the readings are taken. The time in seconds required for the displacement of 100 ml. (6.1 cu. in.) of air through a circular area (one side only) of 6.44 sq. cm. (1 sq. in.) of the paper is known as the air resistance of the paper.

NOTE.—The clamp shall be tested for leakage by substituting a piece of tinfoil 0.05 mm. (0.002 in.) in thickness for the paper and testing in the manner described above. When so tested, the leakage shall not exceed the rate of 50 ml. in five hours.

The proper procedure for clamping the specimen or tinfoil is to turn both knurled nuts down onto the clamp simultaneously. If only one nut at a time is turned down, the clamp will not fit flat on the specimen and will consequently have an avoidable leak.

Oil is used in preference to distilled water because it does not corrode aluminum whereas distilled water does.

Precautions should be taken to avoid subjecting the apparatus to vibration as this condition would increase the rate of air displacement.

Report. 40. The report shall include the following:

(*a*) the number of seconds required for the displacement of 100 ml. (6.1 cu. in.) of air;
(*b*) the area of paper through which the air was displaced;
(*c*) the thickness of the paper as obtained under Sections 8 to 11;
(*d*) the room temperature.

NOTE.—The following values show the probable accuracy obtainable in the air-resistance tests:

AIR RESISTANCE	ACCURACY
40 seconds	± 5 per cent
100 seconds	± 6 per cent
200 seconds	± 8 per cent
300 seconds	± 10 per cent

ASH

Apparatus. 41. A suitable crucible such as platinum, nickel or porcelain, a balance sensitive to 0.1 mg., and a desiccator are necessary for the test.

Specimen. 42. Not less than 2 g. of dry, finely-divided paper from the "moisture determination" sample as obtained in accordance with Section 6 shall be used.

Procedure. 43. The sample shall be transferred rapidly from the weighing bottle containing the dried sample into the crucible. The weighing bottle shall immediately be re-stoppered and re-weighed, and the exact weight of the sample obtained by taking the difference in weights of the weighing bottle and the sample. The sample shall be completely ignited in the crucible, preferably in a muffle furnace, all precautions being taken to prevent loss of ash or sample. The residue of incombustible mineral matter (ash) shall be desiccated, cooled and weighed, and the amount computed as a percentage of the weight of the dried sample.

Report. 44. The amount of ash shall be reported as a percentage of the weight of the dry sample (see Section 7 (*a*)) and also as a percentage of the weight of the undried sample (see Section 7 (*b*)).

ACIDITY OR ALKALINITY

Apparatus. 45. (*a*) A hot water bath, electric hot plate, motor with stirrer, 50-ml. glass burette graduated to 0.1 ml., 250-ml. wide-mouth Erlenmeyer flasks, thermometer graduated to 1° C., covering the range from 50 to 100° C., and a filtering apparatus, are required for the test.

(*b*) The Erlenmeyer flasks and the stirrer shall be of acid-resistant and alkali-resistant glass. The stirrer shall consist of a glass shaft, one end of which shall be fitted to a chuck attached to the motor shaft (see Fig. 3). The other end of the stirrer shall be fashioned into a two-bladed propeller, each blade to be approximately 15 mm. (0.59 in.) long and 6 mm. (0.24 in.) wide. The pitch of the blades and the direction of rotation shall be such as to produce a downward current along the glass shaft when the stirrer is rotated in the liquid, thus preventing spattering.

(*c*) The following reagents shall be required: Solutions of sodium hydroxide (NaOH) and sulfuric acid (H_2SO_4) in water, each being 0.01 *N* in strength; solution of 0.5 g. of phenolphthalein dissolved in 100 ml. of c.p. ethyl alcohol.

Sample. 46. From the original samples obtained in accordance with Section 2 (*a*), a composite sample of at least 5 g. (0.175 oz.) shall be cut into small pieces, approximately 1 cm. (0.4 in.) square. The sample shall be thoroughly mixed, and during preparation contamination by handling shall be avoided.

Procedure.

47. (*a*) ***Extraction.***—One gram of the composite sample shall be placed in a 250-ml. Erlenmeyer flask and 100 ml. of boiling, distilled water added. The flask shall then be clamped in position in a water bath[1] heated to 100° C. on a hot plate. The level of the water in the bath shall be slightly above the level of that in the flask, and the temperature of the contents of the flask shall remain at least as high as 95° C. during the stirring operation. The stirrer shall be mounted so that the blades are within 3 mm. (0.12 in.) of the bottom of the flask and offset from the center in order to obtain best beating action.

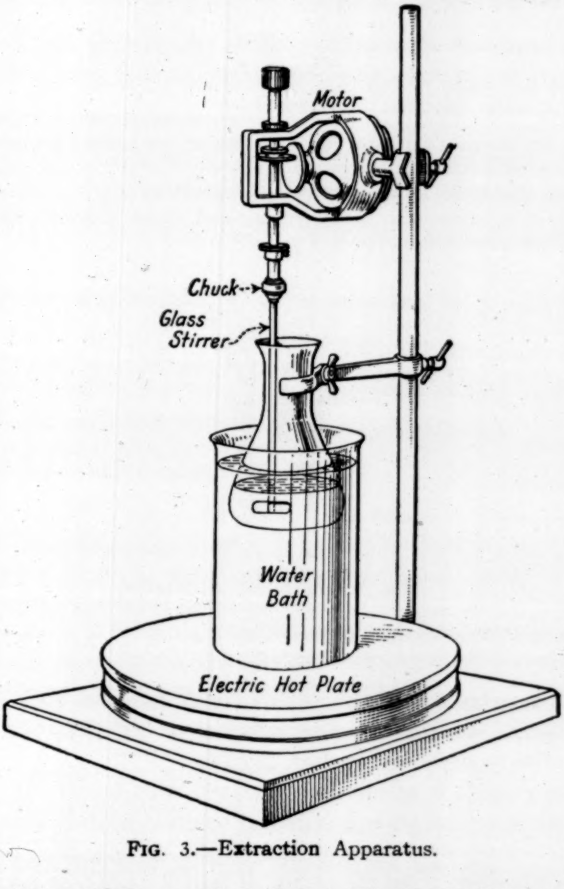


FIG. 3.—**Extraction** Apparatus.

---

[1] At high altitudes a salt bath will be necessary to obtain the temperature required.

The stirrer shall be driven at a speed of 4000 to 5000 r.p.m. for 5 minutes. At the end of this period the sample should have been thoroughly pulped. For papers unusually difficult to pulp, the period of stirring shall be increased to 10 minutes.[1]

NOTE.—It has been definitely determined that 3000 r.p.m. is too low to pulp the sample effectively within 5 minutes.

(*b*) *Titration.*—Immediately after the sample has been pulped, the contents of the flask shall be filtered rapidly into another 250-ml. Erlenmeyer flask without washing.

NOTE.—It is important that the filtration of the extract be accomplished as promptly as possible after disintegration to prevent re-absorption of acidic or alkaline material from the extract by the pulp as the temperature falls. A convenient method consists of a 25-ml. porcelain Gooch crucible and holder assembly, like that shown in Fig. 4. The pulp forms a filter mat of itself over the perforations in the bottom of the crucible and the first portion of the filtrate is re-filtered to catch the fibers which go through during the formation of the mat.

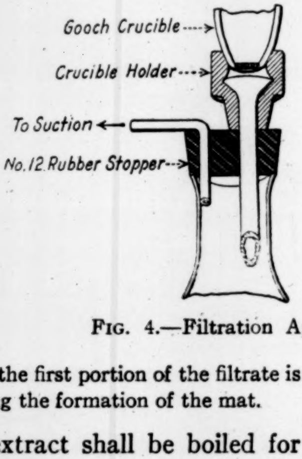


FIG. 4.—Filtration Apparatus.

The filtered extract shall be boiled for 3 minutes and immediately titrated before the temperature falls below 80° C., thus eliminating the error due to dissolved carbon dioxide.

If the extract is acidic, it is titrated with $0.01N$ NaOH, using 5 drops of the specified phenolphthalein solution as indicator. The end-point is determined by the appearance of a definite pink color. If the extract is alkaline, a small excess of $0.01N$ H_2SO_4 is added and the titration then completed with $0.01N$ NaOH as described above.

NOTE.—To find the proper color transformation at the end-point, a blank titration should be made on boiling distilled water under the above specified conditions.

The number of milliliters of titer solution shall be recorded, together with the temperature and volume of the solution taken immediately upon the completion of the titration, as these figures enter into the blank correction for the volume error (E_v).

---

[1] Any other method of pulping the sample as rapidly and thoroughly, while maintaining a temperature of 95° C. within the flask during extraction, should prove satisfactory.

48. (*a*) *Blank Correction.*—The correction for the blank error in the titration shall be made by running a blank in parallel with the actual determination using a volume of pure distilled water equal to that of the extract at the end-point. If the solution is acidic, this blank correction shall be subtracted from the volume of titer used; if alkaline, the correction shall be added. **Report.**

(*b*) *Calculation.*—The acidity or alkalinity shall be calculated from the following equation:

$$\text{Percentage acidity (or alkalinity)} = \left\{ \begin{matrix} \text{milliliters titer} \\ \text{solution (corrected)} \end{matrix} \right\} \times \frac{\text{normality}}{1000} \times 40 \times 100$$

A simpler form is:

$$\text{Percentage acidity (or alkalinity)} = \left\{ \begin{matrix} \text{milliliters} \\ \text{titer (corrected)} \end{matrix} \right\} \times \text{normality} \times 4$$

(*c*) *Expression of Results.*—The results shall be expressed as the equivalent weight per cent of NaOH if the extract is acidic, or as equivalent weight per cent of SO_3 if the extract is alkaline; this percentage being based on the weight of the air-dry sample in grams.

NOTE.—SO_3 is used rather than H_2SO_4 in this calculation as the equivalent weight of SO_3 is identical with that of NaOH, and this makes it possible to express acidity or alkalinity in directly comparable terms.

(*d*) *Number of Tests.*—At least two samples shall be carried through the foregoing procedure. If in duplicate samples the values of percentage acidity or alkalinity do not agree within 0.005, the determinations shall be repeated.

NOTE.—There is given in an appendix to the report of Committee D-9 for 1926,[1] information regarding the details of the foregoing method, and reasons are presented for the selection of the conditions specified.

SURVEY FOR CONDUCTING PATHS

49. The survey for conducting paths in untreated insulating paper is a test to determine the number of conducting paths in the paper as indicated by the number of electrical breakdowns (or points of excessive current flow in thin papers (see Section 50 (*b*)) when relatively large areas of the paper are subjected to a voltage somewhat lower in value than the dielectric strength of the paper when tested in accordance with Sections 2 to 12 of the Tentative Methods of Testing Sheet, Tape, and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 - 34 T) of the American Society for Testing Materials.[2] **Scope.**

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 461 (1926).

[2] See p. 982.

Apparatus. 50. (*a*) The survey shall be made by passing a specimen of the paper between metallic electrodes across which a voltage is impressed. The arrangement of the apparatus may be of any convenient form which will allow the application of the required voltage to a specimen of relatively large area, and will allow the electrical breakdowns to be indicated so that the number of these may be counted.

(*b*) For papers having a thickness of 0.038 mm. (0.0015 in.) or less it has been found preferable to use a detecting device such as a telephone receiver to detect the excessive current through the conducting paths rather than to allow complete electrical breakdown of the specimen. Also, it is preferable to pass one electrode over the paper rather than to draw the paper through between the electrodes.

Specimens. 51. The specimen shall be of relatively large area, such as a pad of tape, or a sheet from each sample of paper (see Section 2 (*a*)).

Procedure. 52. The survey shall be made by passing the specimen between the metallic electrodes at a speed of 30 to 60 ft. per minute. The voltage impressed across the electrodes shall be 100 volts per mil thickness of the specimen if alternating voltage is used, or 141 volts per mil thickness of the specimen if direct voltage is used.

NOTE 1.—If the voltage values specified above prove inconvenient of application, a lower voltage may be used, in which case it is necessary to establish a relationship between the conducting paths at this voltage and at the specified voltage. A lower value of conducting paths will be obtained at the lower voltage.

NOTE 2.—A description of equipment and a procedure which have been found suitable for making this survey of conducting paths in different thicknesses of paper appears in the Appendix.

Report. 53. The report shall include the following:

(*a*) The total number of conducting paths and the conducting paths per unit area.

(*b*) The length, width, area, and thickness of the specimen.

(*c*) The voltage applied expressed in volts, and volts per mil thickness of specimen.

(*d*) The speed of the paper.

DETERIORATION

Apparatus. 54. (*a*) *Baking Oven.*—An electrically-heated oven, equipped with an efficient means of circulating air *within* or *through* the heated chamber, and a suitable fixture upon which the paper specimens may be mounted, shall be used. In case the air is circulated *within* the body of the oven, for example by fan, it is required that the fixture upon which the specimens are mounted be a turntable rotating within the oven at a speed of about 20 r.p.m., so that the specimens shall be uniformly exposed to the oven conditions. In the case of heated air circulating *through* the oven, the fixture holding the specimens may be stationary but it is essential that it shall be mounted so as to be at least 4 in. from the oven walls at any point to permit adequate circulation in all parts of the oven, and the design should be such that there shall be an air velocity of at least one foot per second through the oven.

(*b*) *Testing Equipment.*—In addition to the oven it is necessary to provide testing machines for making physical measurements on the baked specimens. The tests may be tensile breaking strength, tearing strength, folding endurance, or brittleness.[1]

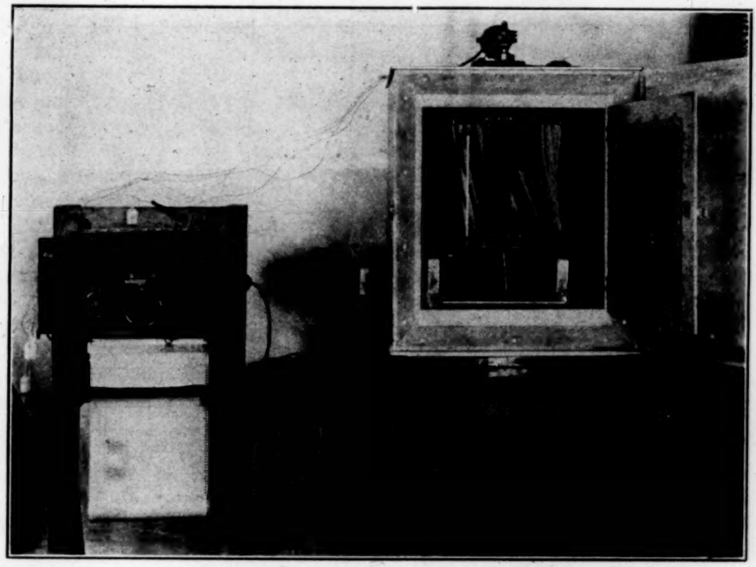


FIG. 5.—Baking Oven Equipped for Circulating Air Within the Oven.

Specimens. 55. (*a*) The specimens shall be at least ½ in. in width and at least 12 in. in length, and shall be cut from samples obtained in accordance with Section 2 (*a*). At least five groups of 5 specimens each shall be selected for each type of physical test noted in Section 54 (*b*). These groups of specimens shall be selected from the gross sample in some rational manner, so as to represent any known or suspected differences in the quality of the product.

Baking. 56. (*a*) The specimens shall be mounted on the fixture as shown in Figs. 5 and 6. In the case of the rotating turntable, Fig. 5, the specimens shall be mounted at such an angle that they will assist, fan-like, in stirring the air within the oven. In the case of a stationary scheme of mounting, Fig. 6, the specimens shall be mounted vertically. The rows of clips supporting the specimens, top and bottom, should be set alternately at 45-deg. angles across the oven so that the air flowing horizontally through the oven would pass between these staggered rows, turbine fashion, and assist in keeping the temperature uniform in all parts of the oven.

---

[1] Another sensitive test for paper deterioration is brittleness strength. This does not appear in the method, but will be included as soon as the test is developed by the committee.

The fixture, readily removable from the oven for mounting the specimens, shall be put in place, and the oven, previously brought to 135° C., shall be closed. Air shall be circulated, as previously indicated, and the temperature shall be maintained at 135° C. ± 2° C. for 96 hours.[1] It is imperative that the differences in temperature in different parts of the oven shall not exceed 2° C.

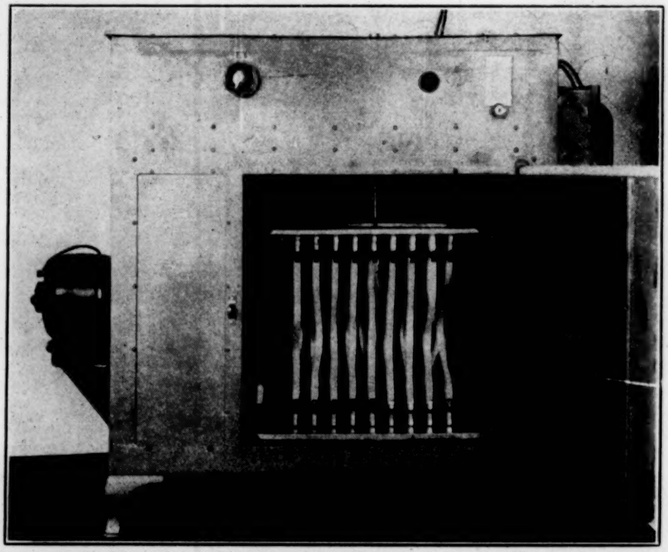


FIG. 6.—Baking Oven Equipped for Circulating Air Through the Oven.

Conditioning and Testing. 57. The baked specimens shall be removed from the mounting fixture, care being taken not to damage the strips, and shall be conditioned in a humidity room at 60 to 65 per cent relative humidity and at a temperature of 68 to 86° F., for a period of 4 hours. They shall then be tested in this conditioned room for tensile breaking strength, tearing strength, folding endurance, or brittleness.[2]

Report. 58. The maximum, minimum and average values shall be reported for each type of test used.

---

[1] These temperature and time conditions are satisfactory for the more stable types of cable insulating papers. Less severe conditions should be used for other insulating papers and these will be included as soon as they are developed by the committee.

[2] Another sensitive test for paper deterioration is brittleness strength. This does not appear in the method, but will be included as soon as the test is developed by the committee.

Appendix

DESCRIPTION OF APPARATUS FOR A SURVEY FOR CONDUCTING PATHS IN UNTREATED INSULATING PAPERS

Equipment and procedure which have been found to be suitable for making the survey of conducting paths for different thicknesses of paper are as follows:

For Paper Having a Thickness of 0.038 mm. (0.0015 in.) or Under.—For paper having a thickness of 0.038 mm. (0.0015 in.) or under, a brass plate, a brass roller with an insulated handle, a pair of telephone receivers having a total resistance of 3000 ohms, a resistor of 80,000 ohms, and a source of direct voltage of 110 volts is used in this test. The brass plate is 31.8 cm. (12.5 in.) in width and 38.7 cm. (15.25 in.) in length and is machined and polished until its surface is level and smooth. The brass roller has a diameter of 5.08 cm. (2 in.) and a face of 2.54 cm. (1.00 in.) in width. The surface of the roller should be accurately cylindrical and polished so that it will always make a line contact when it is rolled over the brass plate in any direction. A brass plate which will warp the least is best obtained by casting a plate at least 2.54 cm. (1.00 in.) in thickness and dressing down the surface to the desired smoothness.

The size of the specimen is 38.7 cm. (15.25 in.) square, and is prepared for test as follows: Using a soft pencil (No. 2) and bearing lightly, mark off 12 swaths on each specimen (see Fig. A1). Each swath is 2.54 cm. (1 in.) in width and 30 cm. (12 in.) in length. The swaths are spaced 0.63 cm. (0.25 in.) from each other. The specimen is then placed on the brass plate in such a manner that the ends of all the swaths are spaced 0.63 cm. (0.25 in.) from the edges of the brass plate. The specimen may be held in position by means of two weights as shown in Fig. A1.

Connect the brass roller to one pole of the 110-volt circuit. Connect the brass plate, the 80,000-ohm resistance and the telephone receivers in series to the other pole of the 110-volt circuit. (See Fig. A1.) Run the brass roller once over each swath slowly in succession and count the clicks audible in the telephone receivers. Each click is considered to represent a conducting path. The total number of clicks counted on all the specimens divided by the total area of all the swaths of all the specimens, is the number of conducting paths per unit area.

For Paper Having a Thickness Greater Than 0.038 mm. (0.0015 in.) and Less Than 0.76 mm. (0.030 in.).—For paper having a thickness greater than 0.038 mm. (0.0015 in.) and less than 0.76 mm. (0.030 in.) a transformer with regulating equipment to give the required voltage, a voltmeter, a source of alternating voltage, a brass plate and a set of brass rollers are used. The brass plate is 15.2 cm. (6 in.) in width and 122 cm. (48 in.) in length and is machined and polished until its surface is level and smooth. Each brass roller has a diameter of 3.81 cm. (1.5 in.) and a face 2.54 cm. (1 in.) in width. The surface of each brass roller is accurately cylindrical and polished so that it makes a line contact when it is placed in its position on the brass plate. The brass rollers are mounted in two parallel rows above the brass plate in such a manner as to permit each individual roller to be raised away from the brass plate or lowered to make a line contact with it. The rollers in each row are spaced and have a common geometric axis. The axes of the two rows of rollers are parallel to each other and also to the long edges of the brass plate. The rollers in one row are staggered with respect to the rollers in the other row so that the surface of paper passing under the first row of rollers will be partially overlapped by the second row of rollers (see Fig. A2). The entire surface of the paper makes contact with the rollers at least once and a part of the surface of the paper will make contact twice. The rollers and plate are adequately insulated from each other.

The specimen is 7.61 meters (25 ft.) in length. Place the specimen between the brass plate and the brass rollers. During the test period the moisture content of the specimen shall not exceed 7 per cent. Lower the brass rollers to make contact with the specimen. Before connecting the transformer to the source of alternating voltage, connect the brass plate to one of the high-voltage terminals of the transformer, and the brass rollers, in multiple, to the other high-voltage terminal of the transformer. Then connect the low-voltage side of the transformer with its regulating equipment to the source of alternating voltage. Adjust the voltage between the brass plate and the brass rollers to the required value (100 volts per mil thickness of the specimen). Pass the specimen along between the rollers and the plate at a speed not to exceed 9.75 m. (32 ft.) per minute and count the number of holes burned in the specimen. Each hole shall be considered as representing a conducting path. The total number of holes counted in all the specimens divided by the total area covered (one side only) of all the specimens is the number of conducting paths per unit area.

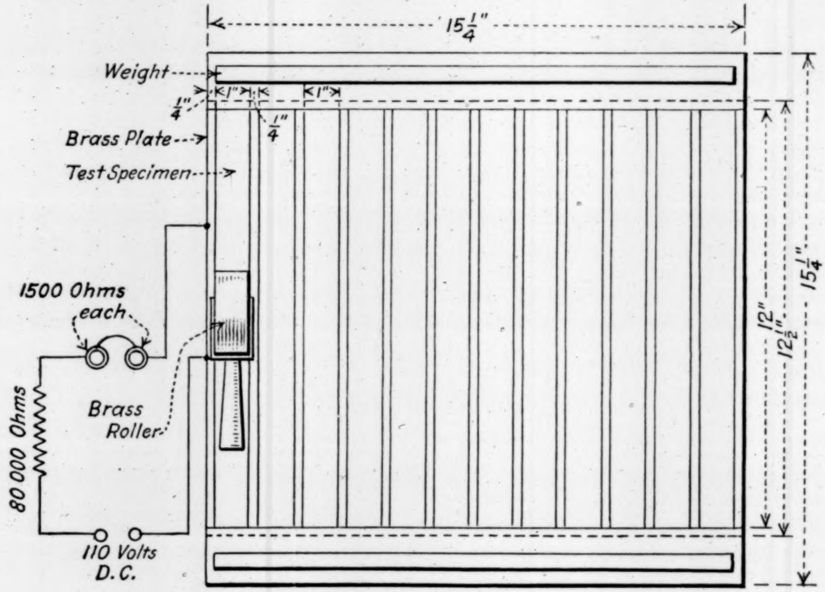


FIG. A1.—Arrangement of Apparatus for Surveying Thin Paper for Conducting Paths.

NOTE.—*Caution:* Disconnect the transformer from the source of alternating voltage before proceeding to place the next specimen between the brass plate and brass rollers.

Specimens in the form of pads of tape may be conveniently tested with an apparatus somewhat similar to the above wherein the pad is mounted on a suitable drum and the entire length of the paper in the pad rerolled on to a second drum, the paper meanwhile passing between two cylindrical rollers across which voltage is applied. The lower roller is somewhat wider than the tape and the upper roller somewhat narrower to prevent arcing through the air between the rollers. The conducting paths are counted by means of a relay and mechanical counter.

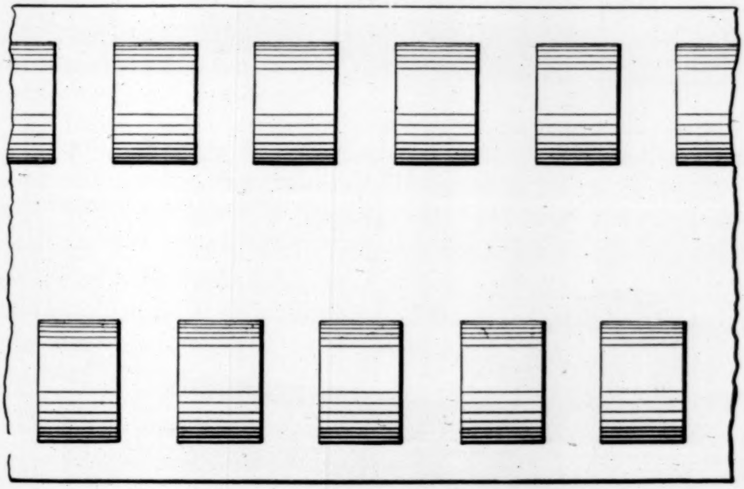
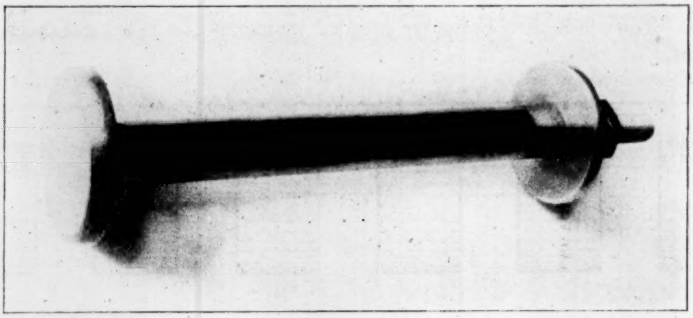
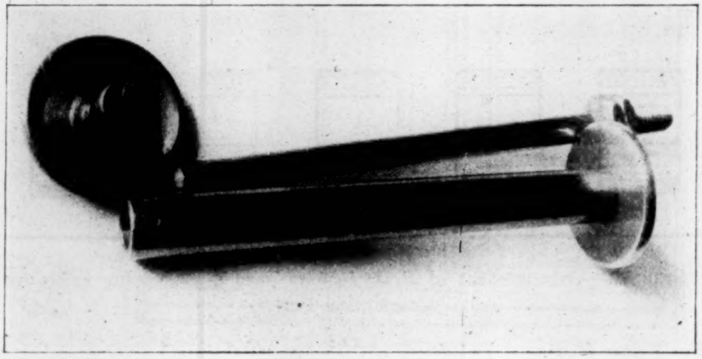


FIG. A2.—Arrangement of Brass Rollers Used in Surveying Paper for Conducting Paths.

For Paper Having a Thickness of 0.76 mm. (0.030 in.) or Over.—For paper having a thickness of 0.76 mm. (0.030 in.) or over a transformer with regulating equipment to give the required voltage, a voltmeter, a source of alternating voltage, a brass plate and a set of disc electrodes are used. The brass plate is 20.3 cm. (8 in.) in width and 122 cm. (48 in.) in length and is machined and polished until its surface is level and smooth. The contact surface of the disc electrodes has a diameter of 3.81 cm. (1.5 in.) with edges rounded to a curvature of 0.64 cm. (0.25 in.) radius. Figure A3 (*a*) shows a convenient design and Fig. A3 (*b*) shows the parts unassembled. The contact surface of each electrode is machined and polished until it is level and smooth and makes an accurate surface contact when it is placed in its position on the brass plate. The disk electrodes are mounted in four parallel rows above the brass plate in such a manner as to permit each individual electrode to be raised away from the brass plate or lowered to make an accurate surface contact with the plate. The four rows of electrodes are parallel to the long edges of the brass plate. The electrodes in one row are staggered with respect to the electrodes in each of the other rows so that the surface of a sheet of paper passing under the electrodes of the first row will be partially overlapped by the electrodes in the second row. Likewise, the surface of paper passing under the electrodes of the second row will be partially overlapped by the electrodes in the third row. And finally, the surface of paper passing under the electrodes of the first and third rows will be partially overlapped by the electrodes in the fourth row. When a sheet of paper has been passed under these four rows of electrodes, the entire surface of the paper will have made contact with the electrodes at least once and a part of the paper surface will have made contact twice. The electrodes and the brass plate should be adequately insulated from each other.



(*a*) Assembled.



(*b*) Unassembled.

FIG. A3.—Disk Electrode for Surveying Paper Over 0.76 mm. in Thickness for Conducting Paths.

The specimen is 7.61 meters (25 ft.) in length. Place the specimen between the disk electrodes and the brass plate. Lower the electrodes to make contact with the specimen, and then proceed as described above for paper 0.038 mm. (0.0015 in.) to 0.76 mm. (0.030 in.) in thickness, except that the specimen is passed between the electrodes and the brass plate at a speed not to exceed 11 m. (36 ft.) per minute. The voltage between the plate and the electrodes should be 100 volts per mil thickness of the specimen.

TENTATIVE METHODS OF TESTING ELECTRICAL INSULATING MATERIALS FOR POWER FACTOR AND DIELECTRIC CONSTANT[1]

A.S.T.M. Designation: D 150 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1922; Revised, 1923, 1927, 1931, 1932, 1934.

Scope. 1. These methods provide for the determination of the power factor and dielectric constant of solid electrical insulating materials at frequencies in the order of:

(*a*) 100 to 1500 kilocycles, the procedure being described in Sections 12 to 23, inclusive;

(*b*) 1000 cycles, the procedure being described in Sections 24 to 30, inclusive.

(*c*) 25 to 60 cycles, the procedure being described in Sections 31 to 36, inclusive.

DEFINITIONS

Power Factor. 2. *Power Factor.*—The power factor of an insulating material is the ratio of the total power loss (watts) in the material to the product of voltage (volts) and current (amperes) in a capacitor in which that material is the dielectric.

Dielectric Constant. 3. *Dielectric Constant.*—The dielectric constant of an insulating material is the ratio of the equivalent parallel capacitance (see Fig. 3) of a capacitor in which that material is the dielectric to the capacitance of a similar capacitor in which the dielectric is a vacuum. (For practical purposes air dielectric is equivalent to a vacuum.)

Loss Factor. 4. *Loss Factor.*—For the purpose of these methods the loss factor of an insulating material is the product of its dielectric constant and the cotangent of its phase angle (θ, Figs. 2 and 4).

Note.—When the cosine of the phase angle is less than 0.1, the cosine and cotangent are practically equal, and loss factor may be calculated from the following formula:

$$\text{Loss factor} = \text{Dielectric Constant, } K \times \text{Power Factor}$$

THEORY OF TEST

Power Factor. 5. (*a*) *Series Notation.*—Any insulating material between two electrodes constitutes a capacitor. Such a physical capacitor may be represented by a capacitance C and a resistance R in *series* as shown in Fig. 1. The resistance R is called the equivalent series resistance and the capacitance C is called the equivalent series capacitance of the capacitor. For sine-wave voltage and current the vector relations are as shown in Fig. 2. The power factor is:

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

$$\text{Power Factor} = \cos\theta = \sin\Psi = \sin\tan^{-1} R\omega C$$

where R = the resistance in ohms;
ω = 2π times the frequency in cycles; and
C = the capacitance in farads.

Since, for small angles the sine is substantially equal to the tangent, the power factor equals $R\omega C$, approximately. This is correct to closer than 0.5 per cent of the power factor value for power factors up to 0.1. Where R is expressed in ohms, C in microfarads and the frequency, f, in kilocycles, this expression becomes:

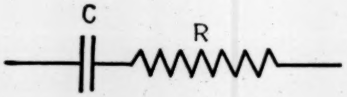


FIG. 1.—Equivalent Series Circuit.

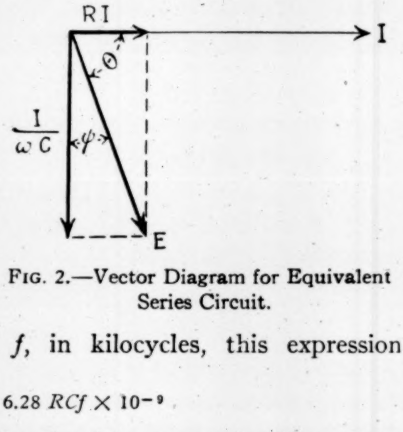


FIG. 2.—Vector Diagram for Equivalent Series Circuit.

$$\text{Power Factor} = 6.28\, RCf \times 10^{-9}$$

The power factor is, therefore, determined by measuring the values of R and C. This may be done by the Substitution Method as described in Sections 15 and 16.

(*b*) *Parallel Notation.*—A physical capacitor may also be represented by a capacitance C_p and a resistance R_p in *parallel* as shown in Fig. 3. The resistance R_p is called the equivalent parallel resistance and the capacitance C_p is called the equivalent parallel capacitance of the capacitor. For sine-wave voltage and current the vector relations are as shown in Fig. 4. For this notation the power factor is:

$$\text{Power Factor} = \cos\theta = \sin\Psi = \sin\tan^{-1}\frac{G}{\omega C_p}$$

where G = the conductance in *mhos;*
ω = 2π times the frequency, in cycles; and
C_p = the capacitance in farads.

Making the same approximations as in Paragraph (*a*), the power factor for practical purposes is taken as $\frac{G}{\omega C_p}$. Where G is expressed in micro-mhos, the frequency, f, in kilocycles, and C_p in micro-micro-farads, this expression becomes:

$$\text{Power Factor} = 1.59 \frac{G\,10^2}{fC_p}$$

It will be seen that G and C_p determine the power factor. They may be measured by the Bridge Method as described in Sections 20 and 21.

The equivalent series capacitance C as determined by the Substitution Method, Sections 15 and 16, and the equivalent parallel capacitance C_p as determined by the Bridge Method, Sections 19 and 20, are not identical; but for power factors up to 0.1 they are equal to within 1 per cent. Either value may be used in calculating the dielectric constant.

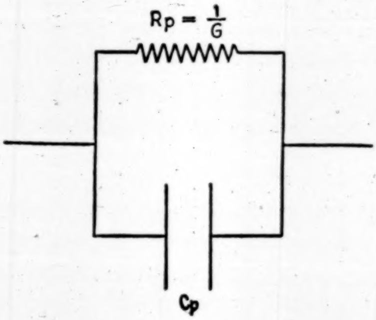


FIG. 3.—Equivalent Parallel Circuit.

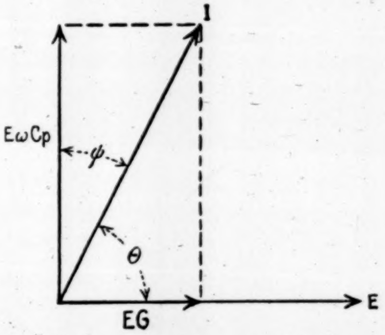


FIG. 4.—Vector Diagram for Equivalent Parallel Circuit.

Dielectric Constant.

6. (*a*) *Sheet Materials.*—For sheet materials, the dielectric constant, K, may be calculated from the following formula:

$$\text{Dielectric constant, } K = \frac{(C - C_e)t}{0.0885A}$$

where t = the average thickness of dielectric between electrodes, in centimeters;

A = the contact area of either of the equal electrodes in square centimeters;

C = the measured capacitance in micro-microfarads;

C_e = the edge correction obtained from the curve in Fig. 5.[1]

The determination of C_e requires a knowledge of the approximate value of K which can always be obtained by making a preliminary calculation, neglecting C_e in the above formula. For thickness t, in inches, and area A, in square inches, the above formula becomes:

---

[1] For details of the determination of the edge correction, see E. L. Hoch, *Bell System Journal*, Vol. V, pp. 555–572c, October, 1926.

$$\text{Dielectric constant, } K = \frac{(C - C_e)\,t}{0.224\,A}$$

(*b*) *Tubes.*—For materials in the form of tubes, the dielectric constant, K, may be calculated from the following formula:

$$\text{Dielectric constant, } K = \frac{3.6\,t\,(C_1 - C_2)}{D\,(l_1 - l_2)}$$

where t = the thickness of the tube in centimeters;
D = the mean diameter in centimeters;

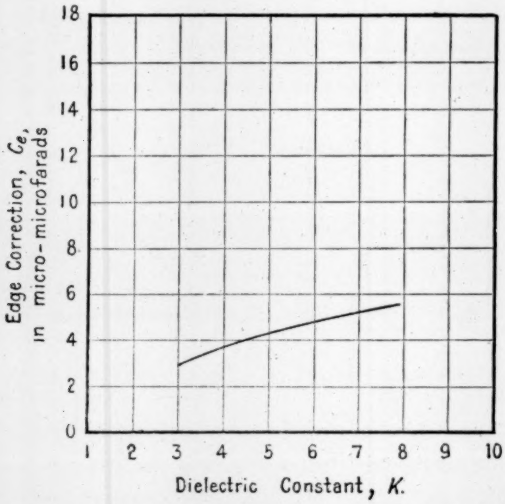


FIG. 5.—Edge Correction Curve for 4.5-in. Diameter Electrodes.

C_1 = the measured capacitance in micro-microfarads when the electrodes have a length of l_1 centimeters; and
C_2 = the measured capacitance in micro-microfarads when the electrodes have a length of l_2 centimeters.

NOTE.—The two measurements C_1 and C_2 are made with different electrode lengths l_1 and l_2 for correction of edge effect.

If the tube thickness is so small, or the electrode length so large that the edge correction may be neglected, then the dielectric constant, K, may be calculated from the following:

$$\text{Dielectric constant, } K = \frac{3.6\,t\,C}{D\,l}$$

where C = the measured capacitance in micro-microfarads for electrodes of length l centimeters.

7. The power loss per unit volume of insulating material for a stated frequency, voltage gradient and temperature is proportional to the product of its dielectric constant and the cotangent of its phase angle (θ, Figs. 2 and 4). Therefore, the loss factor is defined as: **Loss Factor.**

Loss Factor = Dielectric Constant, $K \times$ Cotangent of Phase Angle, θ

NOTE 1.—Sine-wave voltage is assumed.

NOTE 2.—When the cosine of the phase angle is less than 0.1, the cosine and cotangent are practically equal, and loss factor may be calculated from the following formula:

Loss Factor = Dielectric Constant, $K \times$ Power Factor

TEST SPECIMENS

Test Specimens.

8. (*a*) *Molded, Sheet, or Ceramic Materials.*—For testing molded, sheet, or ceramic materials (see also Tubes, Paragraph (*c*)) the test specimen shall be either a disk 6 in. (15.24 cm.) in diameter or a square 6 in. (15.24 cm.) on a side. The thickness shall preferably not be less than 0.1 in. (0.254 cm.) nor more than 0.3 in. (0.762 cm.). The thickness shall be uniform to ±5 per cent, and the surfaces shall be smooth and free from irregularities. Other thicknesses may be used where it is desired to test materials of the various thicknesses in commercial use. In any case, the capacitance of the specimen shall preferably not be less than 100 micro-microfarads.

(*b*) *Films.*—For testing films of insulating varnish, lacquer, or paints, the test specimen shall be prepared as specified for the dielectric strength tests in Appendix II to the Tentative Methods of Testing Varnishes Used for Electrical Insulation (A.S.T.M. Designation: D 115 - 34 T) of the American Society for Testing Materials.[1] The copper or brass plate shall be one capacitor plate, and tin-foil the other. Both varnish films may be tested individually.

(*c*) *Tubes.*—For testing rolled or molded laminated tubes, or ceramic tubes the test specimen shall have the diameter and wall thickness of the material it represents, and shall be of sufficient length to provide a capacitance of not less than 100 micro-microfarads. The thickness shall be uniform to ± 5 per cent, and the surfaces shall be smooth and free from irregularities.

Conditioning of Test Specimens.

9. Before the specimens are tested, they shall be kept for 48 hours under uniform atmospheric conditions. Unless otherwise specified, these conditions shall be a relative humidity of 60 per cent and a temperature of 20 to 30 C. A satisfactory method of maintaining constant humidity is given in Section 13 of the Standard Methods of Test for Resistivity of Insulating Materials (A.S.T.M. Designation: D 257) of the American Society for Testing Materials.[2]

---

[1] See p. 1082.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 1107.

Electrodes.

10. (*a*) *Molded or Sheet Materials.*—The electrodes shall consist of tin or lead-foil disks 4.5 in. (11.43 cm.) in diameter and approximately 0.001 in. or 0.002 in. (0.025 or 0.050 mm.) in thickness. They shall be applied to the surface of the specimen and shall be accurately centered with respect to each other and approximately with respect to the specimen. A very thin coating of petrolatum shall be used as an adhesive.

(*b*) *Films.*—For testing materials of thickness less than 0.1 in. (0.254 cm.), such as thin-sheet insulating materials and films of insulating varnish and lacquer, the electrode area may be adjusted to give any convenient capacitance above 100 micro-microfarads. When calculating the dielectric constant of such materials, the edge correction should be omitted.

(*c*) *Tubes.*—The outer electrode shall consist of tin or lead foil. The inner electrode shall consist either of tin or lead foil, or of mercury. The electrodes shall completely cover the tube surfaces to within $\frac{1}{4}$ in. of the ends of the specimen, shall be centered approximately with respect to the length of the specimen, and shall be located exactly opposite each other.

NOTE.—A very thin coating of petrolatum is a good adhesive for the foil. A cork or a wax plug provides means for holding the mercury in the tube.

Measurements at Other than Room Temperature.

11. It is frequently desirable to measure the losses in materials at temperatures other than room temperature. In order to do this the apparatus for holding the specimen may be placed within an oven for elevated temperatures and a refrigerator for lower temperatures. In either case the temperature shall be controlled accurately. Proper care shall be exercised in carrying the leads from the bridge to the specimen so that they are properly insulated and shielded.

NOTE.—It is desirable to measure the humidity at all temperatures. Humidity may cause changes as large or larger than those caused by temperature.

PROCEDURE AT FREQUENCIES IN THE ORDER OF 100 TO 1500 KILOCYCLES

Method.

12. (*a*) The method of measurement may be either the Substitution Method as described in Sections 13 to 16, or the Bridge Method as described in Sections 17 to 21.

Measurements.

(*b*) The power factor and dielectric constant of at least two specimens shall be measured at such frequencies as may be mutually agreed upon between the supplier and the purchaser. Unless otherwise agreed upon the frequencies shall be approximately 100 kilocycles and 1000 kilocycles.

A. Substitution Method

APPARATUS

Generating Circuit.

13. *Oscillator.*—The generating circuit for the Substitution Method shall consist of an oscillator (preferably a vacuum tube) which is the power source. This oscillator shall be designed so as to be easily adjustable over a range of frequencies from 100 to 1500 kilocycles, and shall have a power rating sufficient to prevent any reaction on frequency or voltage output when coupled to the measuring circuit. The oscillator output shall be of approximately sine-wave form, having not more than 5 per cent harmonic components. The oscillator shall be well shielded. The entire apparatus shall be installed in a well-shielded room or so located as to be free from interference.

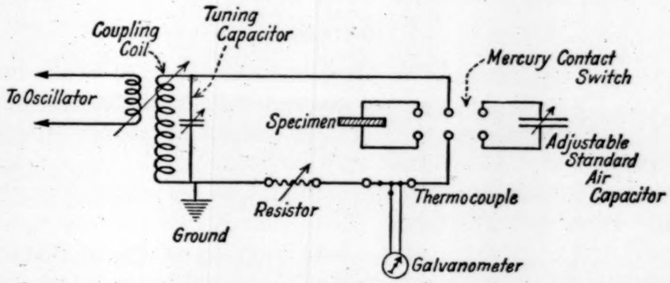


FIG. 6.—Measuring Circuit Diagram for Determination of Power Factor and Dielectric Constant by the Substitution Method.

Measuring Circuit.

14. The measuring circuit is shown in Fig. 6 and shall consist of the following parts:

Coupling Coils.—Several coupling coils so designed as to tune over the required frequency range to within 1 per cent of the frequency desired. For convenience in tuning, an adjustable air capacitor of about 0.001 micro-farads capacity (tuning capacitor) may be connected across the coupling coil. This tuning capacitor should be of the same sensitivity of adjustment as the standard air capacitor, but no calibration is necessary.

Capacitor.—An adjustable standard air capacitor having a capacitance of about 0.001 microfarad capable of being read to 0.5 micromicrofarad. This capacitor shall be calibrated for capacitance and power factor over the required frequency range.

Switch.—A special high-frequency switch of the mercury contact type having mercury cups mounted on Pyrex or quartz tubes 4 to 6 in. (10 to 15 cm.) in length. This switch shall be a double-pole, double-throw, with copper switch blades well amalgamated with mercury.

Thermocouple Galvanometer.—The thermocouple shall have a low heater resistance, preferably less than 2 ohms, and be sufficiently sensitive for use with a suitable galvanometer. The galvanometer shall be of low resistance and short period and shall be operated critically damped. It shall have a sensitivity of approximately 120 mm. per micro-ampere at a scale distance of 1 meter.

Resistors.—Several resistors made of short, straight lengths of non-magnetic resistance wire (advance or manganin is preferable) sealed into glass tubes (which may be evacuated if desired). These resistors shall all have approximately the same length. For most work, 30 resistors to cover a range of 0.2 to 60 ohms will suffice. When resistance values higher than 60 ohms are required, a 3-dial 1000-ohm non-reactive decade box may be used.

METHOD

Operation. 15. (*a*) *Procedure.*—With the specimen connected to the measuring circuit through the mercury contact switch, the circuit shall be tuned to approximately the desired frequency by proper selection of the coupling coil. The circuit may be brought into exact resonance by adjusting the frequency of the oscillator, or by means of the tuning capacitor if the latter is used. Resonance is indicated by maximum deflection of the galvanometer. The coupling to the oscillator shall be varied at the same time so that with no resistance inserted in the measuring circuit, approximately a two-third scale deflection of the galvanometer is obtained.

The adjustable standard air capacitor and a resistor shall then be substituted for the specimen. The resistance should be so chosen that when the measuring circuit is tuned to resonance by adjusting the standard air capacitor, a maximum deflection will be obtained on the galvanometer which is approximately the same as that previously produced by the specimen. Four resistors shall then be chosen having resistance values such that when inserted in the circuit, two will give deflections above and two below the deflection produced by the specimen. The deflections obtained with these four resistors shall be plotted against their resistance values. From this curve the equivalent series resistance R of the specimen shall be obtained by reading the value of resistance corresponding to the deflection produced by the specimen and adding to it the value of the resistance of the standard capacitor at the capacitance and test frequency used.

When a decade resistor is used, the procedure is the same as above except that it is sufficient to adjust the resistor to obtain a deflection equal to that produced by the specimen. The equivalent series resistance R is then equal to the dial reading of the resistance box plus the resistance of the standard air capacitor at the capacitance and test frequency used.

The capacitance reading of the standard air capacitor corrected for lead capacitance is the equivalent series capacitance C of the specimen.

The frequency shall be determined after the final tuning.

(*b*) *Alternative Procedure.*—The circuit for the alternative substitution method is shown in Fig. 7 and consists of a coupling coil, capacitor, switch, thermocouple galvanometer, and resistors as for the Substitution Method and conforming to the requirements of Section 14.

The standard capacitor shall be tuned to resonance, first, with the specimen in parallel and then alone in the circuit. The manipulation and calculations shall be made as follows: With the resistance, R, set to zero and the specimen, C_x, in parallel with the adjustable standard air capacitator, C_s, tune C_s to resonance, read the value of C_s (equals C_1) and the galvanometer deflection d_1. Disconnect the specimen and tune C_s to resonance and read (equals C_2), add resistance R_1, to make galvanometer deflection equivalent to d_1, calculate C_x and R_x from the following formulas:

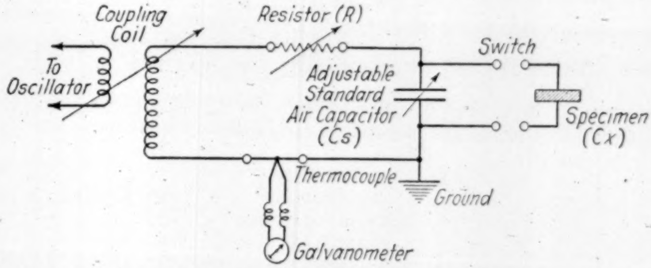


FIG. 7.—Measuring Circuit Diagram for Determination of Power Factor and Dielectric Constant by the Substitution Method (Alternative Procedure).

$$C_x = C_2 - C_1$$

$$R_x = R_1 \left(\frac{C_2}{C_x}\right)^2$$

The power factor shall be calculated from the following formula:

$$\text{Power Factor} = 2\,\pi\,f\,C_x\,R_x$$

where f is expressed in cycles, C_x is expressed in farads and R_x is expressed in ohms.

Calculations. 16. Calculations for power factor shall be made as described in Section 5 (*a*). Calculations for dielectric constant and loss factor shall be made as described in Sections 6 and 7, respectively.

B. Bridge Method

APPARATUS

Generating Circuit. 17. The generating circuit for the Bridge Method shall be the same as for the Substitution Method as described in Section 13.

NOTE.—The oscillator does not need to be of as high a power output for the Bridge Method as for the Substitution Method.

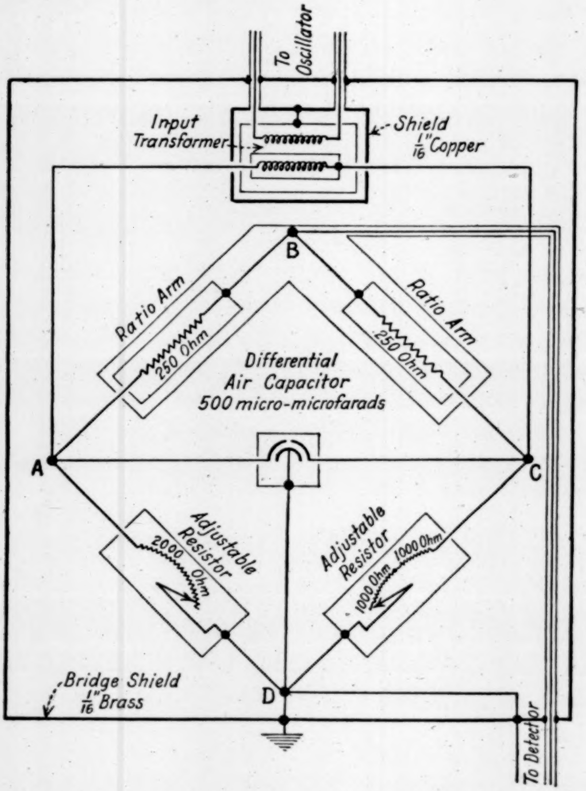

To Oscillator
Input Transformer
Shield $\frac{1}{16}$" Copper
B
Ratio Arm
250 Ohm
Ratio Arm
250 Ohm
Differential Air Capacitor 500 micro-microfarads
A
C
Adjustable Resistor
2000 Ohm
Adjustable Resistor
1000 Ohm
1000 Ohm
Bridge Shield $\frac{1}{16}$" Brass
D
To Detector

FIG. 8.—Measuring Circuit Diagram for Determination of Power Factor and Dielectric Constant by the Bridge Method.

Measuring Circuit. 18. The measuring circuit is shown in Fig. 8 with necessary shielding as indicated, and shall consist of the following parts:

Balanced Resistors.—One pair of balanced non-reactive resistors or ratio arms, *AB* and *BC*, each of approximately 250 ohms resistance, and enclosed in an electrostatic shield as shown in Fig. 8. These arms shall be balanced for resistance to within 0.05 of 1 per cent, and for reactance to within 0.1-micro-microfarad equivalent parallel capacitance.

Adjustable Resistors.—Two non-reactive adjustable resistors each shielded as shown, for use in the *AD* and *CD* arms of the bridge. The *CD* arm resistor shall comprise two 1000-ohm steps. The *AD* arm resistor shall be a four-dial decade box having steps of 0.1, 1, 10, and 100 ohms, with an additional 1000-ohm step. Precision type, high-frequency commercial resistances are satisfactory for use in these resistors.

Differential Air Capacitor.—One differential air capacitor of 500-micro-microfarad capacitance, total variation. For convenience it is desirable to provide a vernier capacitor adjustable to 0.01 micro-microfarad. These capacitors shall be calibrated to read the capacitance inserted in the *CD* arm.

Input Transformer.—One shielded input transformer[1] adapted to the connection of a 250-ohm impedance to the oscillator.

Detector Circuit.

19. The detector circuit shall consist of any suitable detector of sufficient sensitivity to indicate an unbalance of 0.1 ohm in the *AD* bridge arm. A heterodyne type used with a telephone receiver will be found satisfactory.

METHOD

Operation.

20. Suitable leads for connecting to the specimen shall be connected to terminals *C* and *D* of the bridge, Fig. 8, but not to the specimen. The bridge shall then be balanced by adjusting the differential air capacitor and the adjustable arm resistor *AD*. The capacitance and resistance values are then recorded as C_o and R_o. These readings shall be taken to compensate for the capacitance in the bridge and lead wires. The specimen shall then be connected to the lead wires, and the bridge balanced again. The capacitance and resistance values are recorded as C_1 and R_1. The equivalent parallel capacitance of the specimen is: $C_p = C_1 - C_o$, and the conductance $G = \frac{R_o - R_1}{R_o \times R_1}$. By properly adjusting the value of R_o, G can be made substantially equal to $R_o - R_1$ times some power of ten.

The frequency shall be determined when the bridge is finally balanced.

Calculations.

21. Calculations for power factor shall be made as described in Section 5 (*b*). Calculations for dielectric constant and loss factor shall be made as described in Sections 6 and 7, respectively.

---

[1] For general features of such a transformer, see "A Shielded Bridge for Inductive Impedance Measurements at Speech and Carrier Frequencies," by W. J. Shackelton, *Journal*, Am. Inst. Electrical Engrs., February, 1927, p. 159.

ACCURACY

Accuracy.

22. The accuracy of the power factor and dielectric constant determinations by the above methods depend critically upon the care exercised in setting up the measuring equipment and in its subsequent manipulation. The technique exercised in these respects shall be such that an accuracy within ±10 per cent for the determination of power factor, within ±5 per cent for the determination of the dielectric constant of sheets, and within ±10 per cent for the determination of the dielectric constant of tubes shall be obtained.

REPORT

Report.

23. The report shall include the following:

(*a*) The power factor, the dielectric constant, and the loss factor of each specimen.

(*b*) The following values for the specimen: the capacitance of the specimen in micro-microfarads; effective area of the specimen; and the average thickness of the specimen between electrodes.

(*c*) The following test conditions: the frequency in kilocycles; temperature of the atmosphere in degrees Centigrade; relative humidity of the atmosphere in per cent; and the conditioning of the specimen (hours at humidity and temperature).

(*d*) A description of the material: that is, the name, grade, and color, and the name of the manufacturer.

(*e*) Method of measurement.

PROCEDURE AT FREQUENCIES IN THE ORDER OF 1000 CYCLES

Method.

24. (*a*) The method of measurement shall be the bridge method and may be any one of those described in Sections 25 to 28. Slight modifications of any one of these methods may be used with equally satisfactory results.

(*b*) The power factor and dielectric constant of at least two specimens shall be measured at such frequencies as may be mutually agreed upon. Unless otherwise specified, the frequency shall be 1000 cycles.

APPARATUS

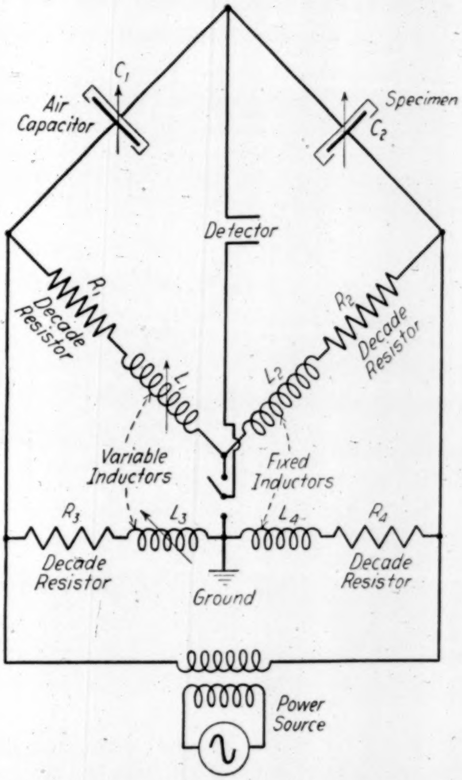
Generating Circuit.

25. *Power Source.*—The generating circuit may be a vacuum tube oscillator, a motor driven generator, or a tuning fork or other satisfactory source of 1000 cycles. The source shall be of approximately sine-wave form, having not more than 5 per cent harmonic components.

Measuring Circuit.

26. Satisfactory measuring circuits, shown in Figs. 9, 10 and 11, are as follows:

(*a*) Figure 9 shows a measuring circuit where C_1 is an auxiliary air capacitor of about 4500 micro-microfarads, C_2 is the specimen being measured or a standard air capacitor. R_1, R_2, R_3, and R_4 are decade resistors. L_1 and L_3 are variable inductors each having a maximum of 12 millihenries and a minimum of 3 millihenries inductance; L_2 and L_4 are fixed inductors each of 11 millihenries. For power factors of less than 0.05 the resistance of the combinations $R_1 + L_1$, $R_2 + L_2$, $R_3 + L_3$ and $R_4 + L_4$ shall be 1000 ohms. For power factors greater than 0.05 these resistances shall be 500 ohms. The capacitance of the test specimen should be between 1000 and 3500 micro-microfarads. For this circuit very satisfactory results have been obtained without increasing the shielding over that built into



C_1
Air Capacitor
Specimen
C_2
Detector
R_1
Decade Resistor
R_2
Decade Resistor
L_1
L_2
Variable Inductors
Fixed Inductors
R_3
L_3
L_4
R_4
Decade Resistor
Ground
Decade Resistor
Power Source

FIG. 9.—Bridge Measuring Circuit for Determination of Power Factor and Dielectric Constant at Frequencies in the Order of 1000 Cycles.

the air capacitors. A 1000-cycle generator giving about 55 volts on the specimen may be used in this set-up as a source of power.

(*b*) Figure 10 shows a measuring circuit where R_1 and R_2 are each 5000 ohms. C_1 is a standard air capacitor, C_s is a standard balancing capacitor of at least 1000 micro-microfarads and C_x is the test specimen. R_3 is a balancing variable resistor of 11,110 ohms which may be thrown in either arm of the bridge containing capacitors. One dial of 0.1 ohm is desirable in this resistor. This set-up may be used satisfactory with any of the following sources of power: a tuning fork, a vacuum tube oscillator and a 1000-cycle generator. The capacitance of the test specimen shall be not less than 100 micro-microfarads. The entire bridge proper is shielded except the leads to the capacitors and the specimen. It has been found desirable to enclose the entire set-up with exception of the oscillator and the detecting device in an earthed metal box.

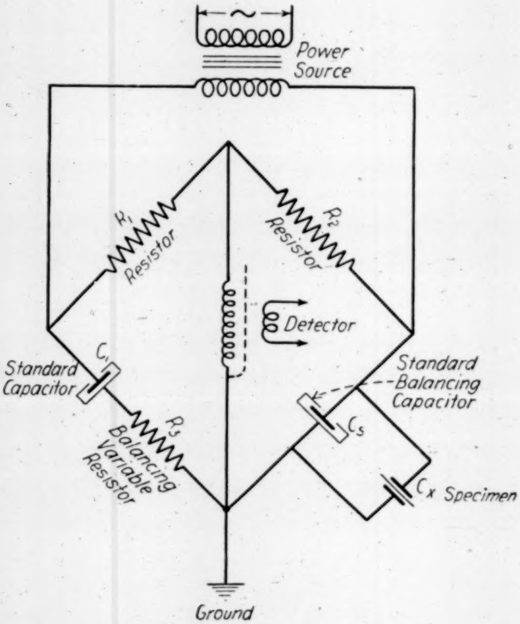
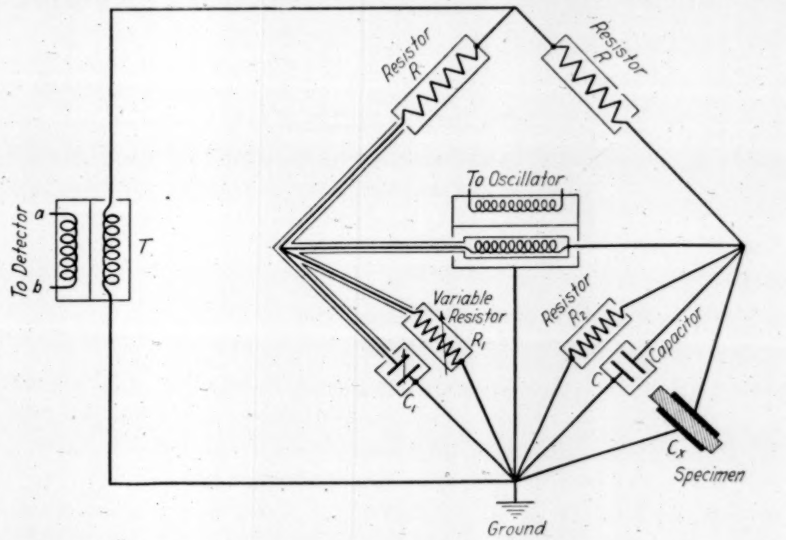

Power Source
R_1
Resistor
R_2
Resistor
Detector
C_1
Standard Capacitor
Standard Balancing Capacitor
R_3
Balancing Variable Resistor
C_s
C_x Specimen
Ground

FIG. 10.—Bridge Measuring Circuit for Determination of Power Factor and Dielectric Constant at Frequencies in the Order of 1000 Cycles.

(*c*) Figure 11 shows a measuring circuit in which the two (ratio) arms each contain a resistance, *R*, of 1000 ohms; R_2 is 10,000 ohms; R_1 is a variable resistor from 0 to 10,000 ohms in steps of 0.01 ohm;

C_x is the test specimen; C is a variable air condenser, the maximum value of which need not exceed 200 micro-microfarads and the calibration of which need not be known; C_1 is a variable standard air condenser with a maximum capacitance greater than the maximum value of $C_x + C$. An oscillator may be used with this set-up which gives about 3 to 8 volts across the specimen. The method is suitable for measurements on test specimens as low as 50 micro-microfarads. It has been found desirable to entirely shield the set-up except for the leads to the test specimen.

NOTE.—Transformer, *T*, Fig. 11, is not necessary if one terminal of the detector may be grounded at *a* or *b*, and with rare exceptions this may be done. The resistors should be specially selected for use in alternating currents of relatively high frequency.



R Resistors, fixed, 1000 ohms each
R_1 Resistor, variable, 10,000 ohms
R_2 Resistor, fixed, 10,000 ohms
C Capacitor, variable, 200 micro-microfarads maximum
C_1 Capacitor, variable, capacity greater than $C + C_x$
C_x Test specimen
T Detector Transformer

FIG. 11.—Bridge Measuring Circuit for Determination of Power Factor and Dielectric Constant at Frequencies in the Order of 1000 Cycles.

27. The detector circuit shall consist of any suitable detector, head phones, string galvanometer, etc., which has a sufficient sensitivity to give values of the power factor accurate to ±5 per cent. **Detector Circuit.**

METHOD

28. The procedure in making the measurements shall be such as to enable the operator to determine the capacitance of the test speci- **Operation.**

men and also its equivalent resistance. The actual manipulation in this regard will depend upon the exact circuit chosen.

Calculation. 29. (*a*) *Power Factor.*—The calculation of the power factor shall be made as described in Section 5 (*a*) and (*b*) with proper modifications as given in the following paragraphs in order to conform to the particular set-up used:

When the measuring circuit described in Section 26 (*a*), Fig. 9, is used, the formula for calculation of the power factor reduces to the following:

$$\text{Power factor} = 2\,\pi\,f\,\frac{(L_2 - L_1)}{R_1}$$

Where L_2 and L_1 are in henries, R_1 is in ohms, and f is in cycles.

When the measuring circuit described in Section 26 (*b*), Fig. 10, is used, the formula for calculation of the power factor is as follows:

$$\text{Power factor} = 2\pi f C_x R_x \times 10^{-12}$$

where C_x = difference in capacitance of the standard capacitor with specimen in and out;

f = the frequency in cycles;

$R_x = (R' - R)\,\dfrac{C'^2_s}{C_x^2}$, where

R' = value of R_3 with specimen out;
R = value of R_3 with specimen in;
C'_s = capacitance of the standard capacitor with specimen out;
C_s = capacitance of the standard capacitor with specimen in;
$C_x = C'_s - C_s$

All values of capacitance in micro-microfarads; resistance is in ohms.

When the measuring circuit described in Section 26 (*c*), Fig. 11, is used, the formula for calculation of the power factor is as follows:

$$\text{Power factor} = \frac{G \times 10^{12}}{2\pi f C_p}$$

where G = the conductance of specimen in mhos calculated as follows:

$$G = \frac{R' - R}{R' \times R}$$

where R' = resistance R_1 with specimen out; and
R = resistance of R_1 with specimen in.

f = the frequency in cycles

C_p = the capacitance of the specimen calculated from the equation: $C_p = C'_s - C_s$

C'_s = capacitance of the standard C_1 with specimen in, and
C_s = capacitance of C_1 with specimen out.

All values of capacitance in micro-microfarads; resistance is in ohms.

(*b*) *Dielectric Constant.*—The calculation of the dielectric constant shall be made as described in Section 6.

(*c*) *Loss Factor.*—The calculation of the loss factor shall be made as described in Section 7.

REPORT

Report.

30. The report shall include the following:

(*a*) The power factor, the dielectric constant, and the loss factor of each specimen.

(*b*) The following values for the specimen: the capacitance of the specimen in micro-microfarads; effective area of the specimen; and the average thickness of the specimen between electrodes.

(*c*) The following test conditions: the frequency in cycles; temperature of the atmosphere in degrees Centigrade; relative humidity of the atmosphere in per cent; and the conditioning of the specimen (hours at humidity and temperature).

(*d*) A description of the material: that is, the name, grade, and color, and the name of the manufacturer.

(*e*) Method of measurement.

PROCEDURE AT COMMERCIAL FREQUENCIES IN THE ORDER OF 25 TO 60 CYCLES

Method.

31. (*a*) The method of measurement shall be the bridge method and may be one of those described in Section 32. Modifications of these methods may be used with equally satisfactory results.

(*b*) The power factor and dielectric constant of at least two specimens shall be measured at such frequencies as may be mutually agreed upon between the manufacturer and the purchaser. Unless otherwise specified, the frequency shall be 60 cycles.

APPARATUS

Generating Circuit.

32. *Power Source.*—The generating circuit or source of power may be any 25 to 60-cycle source, depending upon the frequency agreed upon, which shall be of approximately sine wave form, and not have more than 5 per cent harmonic components.

Measuring Circuit.

33. Satisfactory measuring circuits, shown in Figs. 12 and 13, are as follows:

(*a*) *Parallel Resistance and Capacitance Bridge.*—Figure 12 shows a measuring circuit of the parallel resistance and capacitance bridge type.

The resistors R in the arms AB and BC are each 10,000 ohms.

R_1 is a 111,100-ohm decade resistance box.

R_2 is a 100,000-ohm fixed resistor.

S is a shielded input transformer.

T is a shielded output transformer.

C_1 and C_2 are precision air capacitors of 1000 or 1500 micromicrofarads capacitance.

C_x is the specimen capacitance.

R_x is the equivalent resistance of the specimen.

A suitable detector to be used at T is a vacuum tube voltmeter. Preliminary settings may be obtained even by the use of headphones and the final balance secured with the voltmeter.

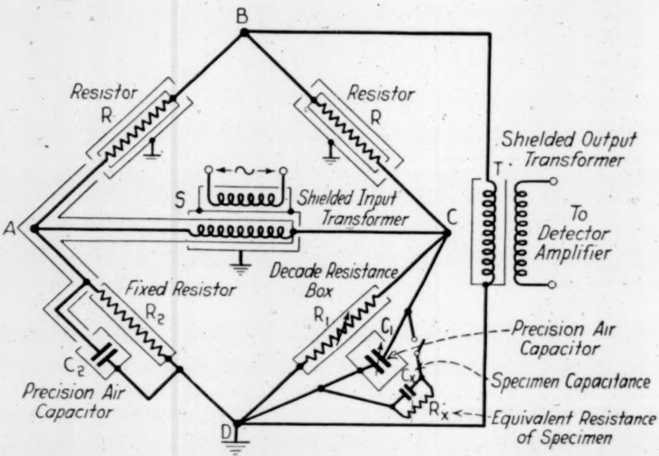

B
Resistor
R
Resistor
R
Shielded Output
Transformer
T
S
Shielded Input
Transformer
A
C
To
Detector
Amplifier
Decade Resistance
Box
Fixed Resistor
R_2
R_1
C_1
C_2
Precision Air
Capacitor
Precision Air
Capacitor
C_x
Specimen Capacitance
R_x
Equivalent Resistance
of Specimen
D

FIG. 12.—Parallel Resistance and Capacitance Bridge for Measurements at 60 to 1000 Cycles per Second.

Any combination of amplifier with indicator, or an a.c. galvanometer combination which has sensitivity to give measurements of power factor accurate to ±5 per cent will be satisfactory.

(*b*) *Schering Bridge.*—Figure 13 shows a measuring circuit of the Schering bridge type.

A and B are the measuring points of the bridge.

C and D are the input points of the bridge.

C_1 is the specimen under test.

C_2 is a guarded air capacitor.

R_3 and R_4 are non-inductive resistors which are variable to 10,000 ohms.

C_3 is ordinarily the residual capacitance of the bridge arm. It

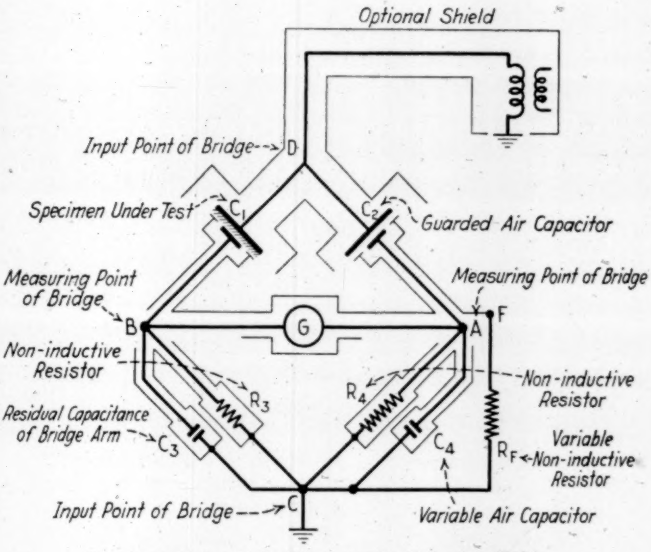

Optional Shield
Input Point of Bridge
D
Specimen Under Test
C_1
C_2
Guarded Air Capacitor
Measuring Point of Bridge
Measuring Point of Bridge
B
G
A
F
Non-inductive Resistor
R_3
R_4
Non-inductive Resistor
Residual Capacitance of Bridge Arm
C_3
C_4
R_F
Variable Non-inductive Resistor
Input Point of Bridge
C
Variable Air Capacitor

FIG. 13.—Schematic Diagram for Schering Bridge.

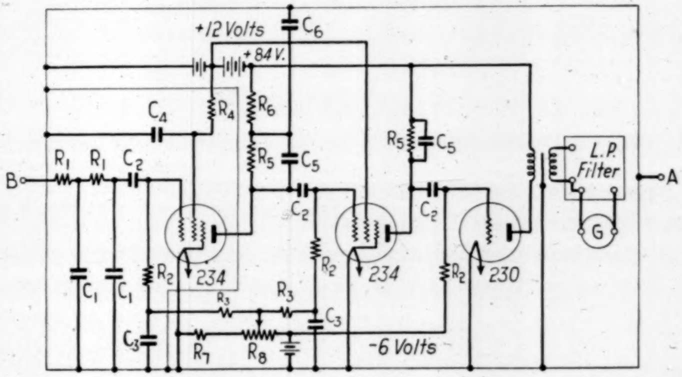

+12 Volts
C_6
+84 V.
C_4
R_4
R_6
R_5
C_5
R_5
C_5
R_1
R_1
C_2
B
L.P. Filter
A
C_2
C_2
G
234
234
230
R_2
R_2
R_2
C_1
C_1
R_3
R_3
C_3
C_3
R_7
R_8
-6 Volts

FIG. 14.—Schematic Diagram for Schering Bridge Amplifier and Galvanometer.

If the amplifier is to be used from 25 to 60 cycles, suitable resistance and capacitance are:

RESISTANCE		CAPACITANCE	
R_1	10 000 ohms	C_1	0.01 μf.
R_2	2 megohms	C_2	0.05 μf.
R_3	0.25 megohms	C_3	1 μf.
R_4	20 000 ohms	C_4	4 μf.
R_5	0.2 megohms	C_5	0.01 μf.
R_6	50 000 ohms	C_6	1 μf.
R_7	1 000 ohms		
R_8	20 000 ohms		

Three 22½-volt "B" batteries of the smallest size and one 22½-volt tapped "C" battery provide plate, screen and grid bias voltages, 84, 12 and −6 volts, respectively.

may be necessary to introduce a small additional capacitance at C_3 when measuring specimens with very small losses.

C_4 is a variable air capacitor of 1000 or 1500 micro-microfarads capacitance. For measuring larger values of power factor an additional capacitor may be shunted across C_4.

R_F is a variable non-inductive resistor of 10,000 ohms. In case it should be found desirable to balance for phase as well as for magnitude, a suitable capacitor should be placed in parallel with R_F.

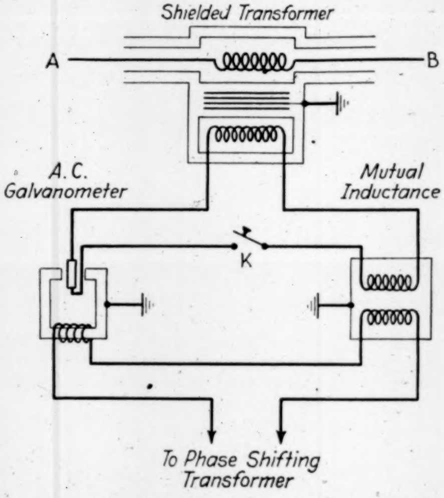


FIG. 15.—Schematic Diagram for Schering Bridge Galvanometer.

The detector for the measuring circuit shown in Fig. 13 may have various forms.

A resistance coupled amplifier that has been found satisfactory as a detector is shown in Fig. 14. This is placed across the bridge at the points *A*, *B*, Fig. 13. At the output of such an amplifier, a low pass filter and a microammeter with a copper oxide rectifier may be used.

Another detector consists of a sensitive a.c. galvanometer in combination with a mutual inductance and phase shifter for balancing, as shown in Fig. 15. For preliminary balances or for relatively large loss specimens, use may be made of a vibration galvanometer, or a string galvanometer having reasonable sensitivity.

METHOD

Operation. 34. The procedure in making the determinations shall be such as to enable the operator to determine the capacitance of the test specimen and also its equivalent resistance. The exact manipulation will depend upon the circuit and the detector chosen.

Calculation

35. (*a*) *Power Factor.*—The calculation of the power factor shall be made as described in Section 5 (*a*) and (*b*) with the proper modifications as given in the following Paragraphs (*b*) and (*c*) in order to conform to the circuit used:

(*b*) *Parallel Resistance and Capacitance Bridge.*—When the measuring circuit described in Section 32 (*a*) and shown in Fig. 12 is used, the formulas for the calculation of the power factor reduce to the following:

$$\text{Power factor} = \cos\theta$$

$$\cot\theta = \frac{1}{2\pi f C_x R_x}$$

where R_X = the resistance of the specimen in ohms and is given by the expression:

$$R_x = \frac{R_1 R'_1}{R'_1 - R_1}$$

R_1 = the resistance of R_1 with the specimen out.
R'_1 = the resistance of R_1 with the specimen in place.

f = the frequency in cycles.
C_x = the capacitance of the specimen and equals $C_1 - C'_1$.

C_1 = the capacitance with the specimen out.
C'_1 = the capacitance with the specimen in place.

In these expressions, all the capacitances are in farads and the resistances are in ohms.

NOTE.—If the power factor is less than 0.1, it may be calculated by the following approximation with not over 0.5 per cent error:

$$\text{Power factor} = \frac{1}{2\pi f C_x R_x}$$

(*c*) *Schering Bridge.*—When the measuring circuit described in Section 32 (*b*) and shown in Fig. 13 is used, the power factor shall be calculated by the following formula:

$$\text{Power factor} = \cos\theta = \cos(\alpha - \beta)$$

where α and β are defined by the following equations:

$$\text{Cot}\ \alpha = 2\pi f C_4 R_4$$
$$\text{Cot}\ \beta = 2\pi f C_3 R_3$$

f = the frequency in cycles.
C_3 and C_4 are in farads.
R_3 and R_4 are in ohms.

NOTE.—Usually C_3R_3 may be made negligibly small in comparison with C_4R_4, in which case the following approximations hold:

$$\text{Power factor} = \cos \theta$$

$$\cot \theta = 2\pi f C_4 R_4$$

If, in addition, the power factor is less than 0.1, then

$$\text{Power factor} = 2\pi f C_4 R_4$$

The equivalent parallel capacitance of the specimen, C_p, is most conveniently calculated from the equivalent series capacitance, C_1, as follows:

$$C_1 = C_2 \frac{R_4}{R_3}$$

$$C_p = \frac{C_1}{1 + \cot^2 \theta}$$

θ is defined in Figs. 2 and 4.

C_2, R_3, and R_4 are defined in Fig. 13.

(*d*) *Dielectric Constant.*—The calculation of the dielectric constant shall be made as described in Section 6. If a guarded specimen is used no edge correction will be necessary but proper consideration shall be given only to the real area of the shielded electrode.

(*e*) *Loss Factor.*—The loss factor shall be calculated as described in Section 7.

REPORT

Report. 36. The report shall include the following:

(*a*) The power factor, the dielectric constant, and the loss factor of the specimen.

(*b*) The following values for the specimen: the capacitance of the specimen in micro-microfarads, the effective area of the specimen, and the average thickness of the specimen between the electrodes.

(*c*) The following test conditions: the frequency in cycles, the temperature of the specimen during test in degrees Centigrade, the relative humidity as a percentage of the atmosphere surrounding the specimen, the conditioning of the specimen, the voltage gradient and the kind of electrodes.

(*d*) A description of the material; that is, the name, grade, color, and the name of the manufacturer.

(*e*) The method of measurement.

TENTATIVE METHODS OF TESTING LAMINATED ROUND RODS USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 349 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1932; REVISED, 1934.

Scope

1. These methods are intended to apply to laminated round rod materials to be used as electrical insulation.

TENSILE STRENGTH

Apparatus

2. Any standard type of testing machine may be used provided it is accurate to within 1 per cent of the lowest load for which it is used. Jaws which tighten under load, such as wedge grip jaws, shall be used with the specimen properly aligned.

Specimens

3. The specimens shall be about 12 in. in length. When the diameter of the rod is $\frac{1}{4}$ in. or over, a lathe cut 1 in. in width and $\frac{1}{32}$ in. in depth with corners rounded to a radius of 3 in. shall be made around the rod at the center.

Procedure

4. Five specimens shall be tested.

Temperature

5. All tests shall be made at normal room temperature of about 20 C. (68 F.).

Speed of Testing Machine

6. The cross-head speed of the testing machine shall be such that the load can be accurately weighed but shall not exceed 0.05 in. per minute when the machine is running idle.

Report

7. The report shall include the following:

(*a*) The diameter of the specimen.

(*b*) The breaking load of each specimen in pounds or kilograms.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

(*c*) The tensile strength of each specimen in pounds per square inch or kilograms per square centimeter.

(*d*) The room temperature.

FLEXURAL STRENGTH

Apparatus

8. (*a*) Any standard type of testing machine may be used provided it is accurate to within 1 per cent of the lowest load for which it is used.

(*b*) The specimen shall be tested as a simple beam loaded at the center. The supports shall have contact edges rounded to a radius of ⅛ in. The distance between the points of support shall be 4 in. when the diameter of rod is ½ in. or over. For smaller rods the distance between supports shall be eight times the diameter of the rod. The load shall be applied through a steel block having a semi-circular contact edge of the same radius as the rod with edges rounded to a radius of ⅛ in.

Specimens

9. The specimen shall be 5 in. in length.

Procedure

10. Five specimens shall be tested.

Report

11. The report shall include the following:

(*a*) The diameter of the specimen.

(*b*) The breaking load of each specimen in pounds or kilograms.

(*c*) The maximum fiber stress in pounds per square inch or kilograms per square centimeter, calculated according to the following formula:

$$S = \frac{8\,WL}{\pi d^3}$$

where S = the maximum fiber stress;
W = the breaking load in pounds or kilograms;
L = the distance between supports in inches or centimeters;
d = the diameter in inches or centimeters.

COMPRESSIVE STRENGTH

Apparatus

12. Any standard type of testing machine may be used provided it is accurate to within 1 per cent of the lowest load for which it is used. One end of the specimen shall bear upon an accurately centered spherical bearing block, located whenever practicable, at the top.

The metal-bearing plates shall be directly in contact with the ends of the test specimen.

Specimens

13. Samples shall be tested as received in specimen lengths of 1 in. The ends shall be accurately cut or ground square with the sides.

Procedure

14. Five specimens shall be tested with the load applied perpendicular to the faces or ends of the specimen.

Report

15. The report shall include the following:

(*a*) The diameter of the specimen.

(*b*) The load on each specimen in pounds or kilograms at the first sign of rupture.

(*c*) The ultimate compressive strength in pounds per square inch or kilograms per square centimeter calculated from the data obtained on the application of the load perpendicular to the face of the specimen.

DENSITY

Specimens

16. Two specimens shall be tested. Any suitable size specimen may be used. The samples used for the compressive strength test, Section 13, will be found convenient.

Procedure

17. Any suitable weight-difference apparatus for making readings in water and air, or the weight and dimensions of the specimen may be used as a basis for calculating the density.

Report

18. The report shall express the density in c.g.s. units.

WATER ABSORPTION TEST

Rate of Absorption

Specimen

19. The test specimen shall be 1 in. in length for rods 1 in. in diameter or under, and ½ in. in length for larger diameter rods. The diameter of the specimen shall be the diameter of the rod. The specimen shall be cut from the sample with a smooth cutting saw. The cut edges shall be finished with No. 0 or finer sandpaper or emery

cloth. Sawing and sand-papering operations shall be slow enough so that the material is not heated appreciably. The thickness in inches to the nearest 0.001 in. shall be measured at the center of the specimen.

Procedure

20. To determine the rate of absorption, two specimens shall be tested individually as follows:

(*a*) The specimen shall be weighed, dried in an oven for 1 hr. at a temperature between 105 and 110 C. (220 and 230 F.), cooled in a desiccator and immediately re-weighed. The difference between the original weight and the dry weight shall be recorded as loss in weight on drying. The percentage loss in weight shall be calculated on the original weight.

(*b*) The dried specimen shall then be immersed in distilled water maintained at a temperature of 25 C. ± 2 C. (77 F. ± 3.6 F.) throughout the test. At the end of 2 hr., the specimen shall be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed immediately, and then replaced in the water. The difference between the weight of the wet specimen and that of the dry specimen shall be recorded as the weight of water absorbed in 2 hr. The percentage of water absorbed in 2 hr. shall be calculated on the weight of the dry specimen.

(*c*) After 24-hr. immersion, the specimen shall again be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed. The difference between the weight of the specimen after 24-hr. immersion and the weight of the dry specimen shall be recorded as the water absorbed in 24 hr. The percentage of water absorbed in 24 hr. shall be calculated on the weight of the dry specimen. If the individual 24-hr. absorptions differ by more than 10 per cent from the average absorption of the two specimens, the test shall be repeated.

Report

21. The report shall include the values for each of the two specimens and the average values as follows:

(*a*) The diameter and length of the specimen before the test, to the nearest 0.001 in.

(*b*) The percentage loss in weight on drying calculated on the original weight.

(*c*) The percentage of water absorbed in 2 hr. and in 24 hr. calculated on the dry weight.

TENTATIVE METHODS OF TESTING SHEET AND PLATE MATERIALS USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 229 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1925; Revised, 1926, 1928, 1930, 1931, 1932, 1934.[2]

Scope. 1. These methods are intended to apply to stiff, flat sheet and plate materials, such as phenolic and other types of laminated sheets, vulcanized fiber, hard rubber, asbestos composition board, etc., to be used as electrical insulation.

Definition of Terms. 2. In referring to the cutting of the specimens and the application of the load, the following definitions apply:

Flatwise.—Load applied to the flat side of the original sheet or plate.

Edgewise.—Load applied to the edge of the original sheet or plate.

Lengthwise.—In the direction of the length of the sheet.

Crosswise.—In the direction at right angles to the length of the sheet.

Note.—When the sheet has the same length and width, one dimension shall arbitrarily be designated as the length, and the other as the width.

TENSILE STRENGTH

Apparatus. 3. Any standard type of testing machine may be used. The machine shall be accurate to within 1 per cent on the lowest load for which it is used. Jaws which tighten under load, such as wedge grip jaws, shall be used with the specimen properly aligned.

Specimens. 4. Tension test specimens shall conform to the dimensions shown in Fig. 1. The surfaces of the specimen shall be smooth and free from scratches.

Procedure. 5. Five specimens cut lengthwise and five specimens cut crosswise of the sheet shall be tested.

Temperature. 6. All tests shall be made at normal room temperature of about 20° C. (68° F.).

---

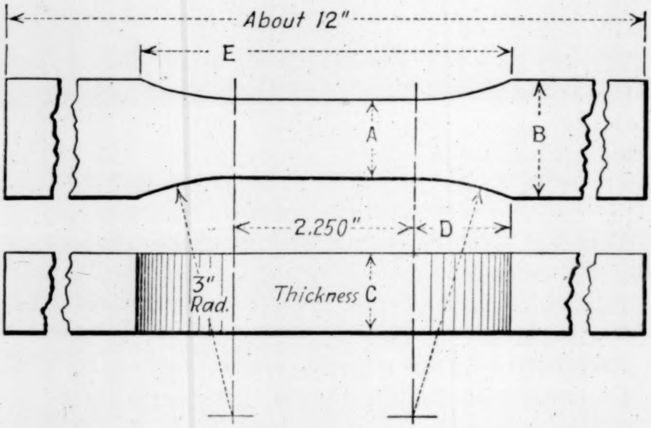
[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

Speed of Testing Machine. 7. The cross-head speed of the testing machine shall be such that the load can be accurately weighed, but shall not exceed 0.05 in. per minute when the machine is running idle.

Modulus of Elasticity. 8. When it is desired to determine the elongation under load, a suitable extensometer measuring the elongation on a 2-in. gage length shall be used. The cross-head speed of the testing machine shall not exceed 0.03 in. per minute when the machine is running idle.

Procedure. 9. The total change in length between zero load and a stress of 5000 lb. per sq. in. shall be determined.



When C is less than $\frac{1}{8}$ in., A is $\frac{1}{2}$ in., B is $\frac{3}{4}$ in., D is 0.857", E is 3.964 in.
When C is $\frac{1}{8}$ in. or over, A is 1 in., B is $1\frac{1}{2}$ in., D is 1.199", E is 4.648 in.

FIG. 1.—Tension Test Specimen for Laminated Sheet Insulating Materials.

Report. 10. The report shall include the following:

(*a*) The direction in which the specimen was taken, whether lengthwise or crosswise of the sheet.

(*b*) The thickness and width of each specimen in inches or centimeters.

(*c*) The breaking load of each specimen, in pounds or kilograms.

(*d*) The tensile strength of each specimen, in pounds per square inch or in kilograms per square centimeter.

(*e*) The location and nature of the fracture.

(*f*) The elongation in inches at a stress of 5000 lb. per sq. in., if determined.

(*g*) The room temperature.

FLEXURAL STRENGTH

(FORMERLY CALLED TRANSVERSE STRENGTH)

(*A*) *For Materials $\frac{1}{32}$ in. or Over in Thickness*[1]

Apparatus.

11. (*a*) Any standard type of testing machine may be used. The machine shall have an accuracy of at least 1 per cent of the lowest load for which it is used.

(*b*) The specimen shall be tested as a simple beam loaded at the center. The supports shall have contact edges rounded to a radius of ⅛ in. for material ⅛ in. or over in thickness, and to a radius of $\frac{1}{16}$ in. for thinner materials. For material thinner than ⅛ in. both supports shall be provided with a pin or other stop to align one side of the specimen perpendicular to the line of contact with the supports. The distance between the points of support shall be 4 in. for edgewise tests of all thicknesses and eight times the nominal thickness of the material to be tested for tests in the flatwise direction, except that the minimum span shall be ½ in.

Specimen.

12. The test specimen shall be ½ in. in width except for specimens over ½ in. in thickness tested in the flatwise direction, which shall have the width equal to the thickness of the specimen. The thickness shall be the full thickness of the sheet. The length shall be 1 in. greater than the distance between the points of support as specified in Section 11 (*b*).

Procedure.

13. The specimens shall be tested as follows:

(*a*) Five specimens cut lengthwise of sheet, tested flatwise.

(*b*) Five specimens cut lengthwise of sheet, tested edgewise.

(*c*) Five specimens cut crosswise of sheet, tested flatwise.

(*d*) Five specimens cut crosswise of sheet, tested edgewise.

Temperature of Tests.

14. All tests shall be made at normal room temperature of about 20° C. (68° F.).

Speed of Testing Machine.

15. The cross-head speed of the testing machine shall be such that the beam of the machine can be kept balanced, but shall not exceed 0.05 in. per minute when the machine is running idle.

Report.

16. The report shall include the following:

(*a*) The directions of cutting and loading of the specimen as specified in Section 13.

(*b*) The thickness and width of each specimen in inches or millimeters.

(*c*) The breaking load of each specimen in pounds or kilograms.

---

[1] Conventional flexure tests in a flatwise direction are not recommended for materials thinner than $\frac{1}{32}$ in. nor in the edgewise direction for materials thinner than ¼ in.

(*d*) The maximum fiber stress in pounds per square inch or kilograms per square centimeter calculated from the formula:

$$S=\frac{3}{2}\frac{Pl}{bd^2}$$

where S = maximum fiber stress;
P = breaking load in pounds or kilograms;
l = distance between supports in inches or centimeters;
b = width of specimen in inches or centimeters;
d = depth of specimen in inches or centimeters.

(*e*) The room temperature.

COMPRESSIVE STRENGTH

Apparatus. 17. Any standard testing machine may be used provided it is accurate within 1 per cent of the lowest load for which it is used. One end of the specimen shall bear upon an accurately centered spherical bearing block, located whenever practicable, at the top, and the metal bearing plates shall be directly in contact with the ends of the test specimen.

Specimen. 18. (*a*) For sheets 1 in. in thickness or over, the test specimen shall be a 1-in. cube, the faces of which shall be flat and perpendicular to the axes, being ground to this condition if necessary.

(*b*) For sheets less than 1 in. in thickness, the specimen shall consist of a pile of sheets 1 in. square with a minimum number of layers to produce a height of at least 1 in.

Procedure. 19. (*a*) For sheets 1 in. in thickness or over, three specimens shall be crushed in the condition in which they are received with the load applied flatwise, three specimens with the load applied edgewise-lengthwise of the sheet and three specimens with the load applied edgewise-crosswise of the sheet.

(*b*) For sheets less than 1 in. in thickness, three specimens shall be crushed in the condition in which they are received with the load applied flatwise of the sheet.

20. The load shall be applied on the ends of the specimen and the crosshead speed of the testing machine shall be such that the load can be accurately weighed but shall not exceed 0.050 in. (1.27 mm.) per minute when the machine is running idle. For the best results use the slowest possible speed.

Report. 21. The report shall include the following:

(*a*) The dimensions of each specimen in inches or millimeters;

(*b*) The direction of application of the load;

(*c*) The load on each specimen in pounds or kilograms at the first sign of failure;

(*d*) The ultimate compressive strength in pounds per square inch or kilograms per square millimeter, of each specimen, calculated from the area of each specimen measured before the load is applied;

(*e*) The general character of the material tested; with a description of how it acts under the applied load.

WATER ABSORPTION TESTS

22. The water absorption tests are intended to determine the rate at which water is absorbed by the material when immersed, the total quantity absorbed at saturation, and the volatile content as received. **Scope.**

NOTE.—The electrical properties of different materials are not necessarily affected to the same extent by the same increase in moisture content so that the water absorption test must be correlated with the desired electrical tests.

The water immersion test and exposure to air of high humidity are not always directly comparable and should be considered before substituting one for the other.

(*A*) *Rate of Absorption*

23. The test specimen shall be 3 by 1 in. by the thickness of the material. It shall be sawed or sheared from the sample so as to have smooth edges free from cracks. The cut edges of all test specimens shall be finished with No. 0 or finer sandpaper or emery cloth. Sawing and sandpapering operations should be slow enough so that the material is not heated appreciably. The thickness in inches to the nearest 0.001 in. shall be measured on the original specimen at the center. **Specimen.**

24. To determine the rate of absorption, two specimens shall be tested individually as follows: **Procedure.**

(*a*) The specimen shall be weighed, dried in an oven for 1 hour at from 105 to 110° C., cooled in a desiccator and immediately re-weighed. The difference between the original weight and the dry weight shall be recorded as loss in weight on drying. The percentage loss in weight shall be calculated on the original weight.

(*b*) The dried specimen shall then be immersed in distilled water maintained at a temperature of 25° C. ± 2° C. (77° F. ± 3.6° F.) throughout the test. At the end of 2 hours the specimen shall be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed immediately and then replaced in the water. If the specimen is $\frac{1}{16}$ in. in thickness or less it shall be weighed in a weighing bottle. The difference between the weight of the wet specimen and that of the dry specimen shall be recorded as the weight of water absorbed in 2 hours. The percentage of water absorbed shall be calculated on the weight of the dry specimen.

(*c*) After 24 hours immersion the specimen shall again be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed. The difference between the weight of the specimen after 24 hours immersion and the weight of the dry specimen shall be recorded as the water absorbed in 24 hours. The percentage of water absorbed shall be calculated on the weight of the dry specimen. If the individual 24-hour absorptions differ by more than 10 per cent from the average absorption of the two specimens the test shall be repeated.

Report. 25. The report shall include the values for each of the two specimens and the average values as follows:

(*a*) The thickness of the specimen before the test, to the nearest 0.001 in.;

(*b*) The percentage loss in weight on drying calculated on the original weight;

(*c*) The percentage of water absorbed in 2 hours and in 24 hours calculated on the dry weight.

(*B*) *Total Absorption at Saturation*

Specimen. 26. (*a*) The test specimen shall be 3 by 1 in. by the thickness of the material. It shall be sawed or sheared from the sample so as to have smooth edges free from cracks. The cut edges of all test specimens shall be finished with No. 0 or finer sandpaper or emery cloth. Sawing and sandpapering operations should be slow enough so that the material is not heated appreciably. The thickness in inches measured to the nearest 0.001 in. shall be measured on the original specimen at the center and on the reduced specimen in case a reduced specimen is used (see Paragraph (*b*)).

(*b*) When the sample for determining total absorption is so thick that too long a time is required for saturation using the full thickness, the thickness may be reduced as follows: The sample shall be machined to a thickness of about $\frac{5}{64}$ in., both surfaces parallel to the laminations being machined off. This may readily be done with a smooth-cut circular saw. It shall then be sanded to $\frac{1}{16}$ in. in thickness, finishing with No. 0 or finer sandpaper. While the sanded surfaces of the sample should be approximately parallel with the laminations, the thickness may vary ±0.010 in., since the object is to provide comparable specimens which will reach saturation in a reasonable time. The machined and sanded sample shall then be cut into specimens 3 by 1 in. and the edges sanded.

Procedure. 27. To determine the total water absorption at saturation, two specimens shall be tested individually as follows:

(*a*) The specimen shall be weighed, dried in an oven for 1 hour at from 105 to 110° C., cooled in a desiccator and immediately reweighed. The difference between the original weight and the dry weight shall be recorded as loss of weight on drying. The percentage loss in weight shall be calculated on the original weight.

(*b*) The dried specimen shall then be immersed in distilled water at a temperature of from 20 to 30° C. At the end of 24 hours the specimen shall be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed immediately and then replaced in the water. The weighings shall be repeated every day for the first week and every week thereafter until the increase in weight, as shown by three consecutive weighings, averages less than 1 per cent of the total increase in weight, when the specimen shall be considered to be saturated.

(*c*) The difference between the saturated weight and that of the dry weight shall be considered as the water absorbed at saturation. The percentage of water absorbed shall be calculated on the dry weight of the specimen.

Report. 28. This report shall include the values for each of the two specimens as follows:

(*a*) The original thickness of material, measured to the nearest 0.001 in.;

(*b*) If a reduced specimen is used, the thickness measured to the nearest 0.001 in.;

(*c*) The percentage loss in weight on drying, calculated on the original weight;

(*d*) The percentage of water absorbed at saturation, calculated on the dry weight.

(*C*) *Volatile Matter*

Specimen. 29. The test specimen shall conform to the requirements specified in Section 12.

Procedure. 30. To determine the volatile matter, two specimens shall be tested individually as follows:

The specimen shall be weighed, dried in an oven at from 105 to 110° C. until the decrease in weight as shown by two consecutive weighings at least 24 hours apart is less than 1 per cent of the total decrease in weight. The difference between the original weight and the dry weight shall be recorded as the volatile matter present in the specimen as received (this includes in addition to water any volatile solvent left during manufacture). The percentage of volatile matter shall be based on the weight of the dry specimen.

Report. **31. The report shall include the values for each of the two specimens as follows:**

(*a*) The original thickness of the material measured to the nearest 0.001 in.;

(*b*) The percentage of volatile matter, based on the weight of the dry specimen.

DIELECTRIC STRENGTH

Dielectric Strength. **32. The dielectric strength shall be determined in accordance with** the Tentative Methods of Testing Sheet, Tape, and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 - 34 T) of the American Society for Testing Materials.[1]

PHASE DIFFERENCE (POWER FACTOR) AND DIELECTRIC CONSTANT

Dielectric Constant. 33. The phase difference and dielectric constant shall be determined in accordance with the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (A.S.T.M. Designation: D 150 - 34 T) of the American Society for Testing Materials.[2]

BONDING STRENGTH

For Laminated Materials $\frac{3}{16}$ in. or Over in Thickness

Apparatus. 34. Any standard type of testing machine may be used, providing it is accurate within 1 per cent of the lowest load for which it is used. To this shall be fitted a head containing a 10-mm. steel ball.

Specimens. 35. Test specimens shall be 1 in. square, smoothly and accurately cut on a smooth saw.

Procedure. 36. Five specimens shall be tested. These shall be placed on edge and the steel ball shall center accurately between the edges and ends of the specimen.

Temperature. 37. All tests shall be made at normal room temperature of about 20° C. (68° F.).

Speed of Testing Machine. 38. The speed of the cross-head of the testing machine shall be such that the load can be accurately weighed, but shall not exceed 0.05 in. per minute when the machine is running idle.

Report. 39. The report shall include the following:

(*a*) the thickness of the material; and

(*b*) the load, expressed in pounds or kilograms, required to split the specimen.

---

[1] See p. 982.

[2] See p. 1029.

ROCKWELL HARDNESS

40. (*a*) The Rockwell hardness tester shall be used, conforming to the requirements of the Tentative Methods of Rockwell Hardness Testing of Metallic Materials (A.S.T.M. Designation: E 18 – 33 T) of the American Society for Testing Materials.[1] **Apparatus.**

(*b*) The hardness shall be determined using a $\frac{1}{4}$-in. diameter ball penetrator, a minor load of 10 kg. and a major load of 100 kg., the readings being taken on the black figures.

41. (*a*) The specimen shall have a minimum thickness of $\frac{1}{4}$ in. The specimen may be composed of a pile-up of several pieces of the material of the same thickness, providing that precaution is taken that the surfaces of the pieces are in contact and not held apart by burrs from saw cuts, etc. The area of the specimen shall be 1 in. square if cut from sheet stock or other shape of at least this area. **Specimen.**

(*b*) Care shall be taken that the test is not made so near the edge of the specimen that it will break out when the major load is applied.

(*c*) The specimen shall be supported in such a manner as to prevent errors due to overhang, when it does not balance itself on the anvil.

(*d*) All tests shall be made at normal room temperature of about 20° C. (68° F.).

NOTE.—It should be noted that some materials such as laminated phenolic plates show an appreciable variation in the Rockwell hardness with variation in temperature as small as 8° C. (15° F.).

42. The procedure outlined in the Tentative Methods E 18 – 33 T[1] shall be followed. The adjustment of speed of load application and the time of application of the major load are of great importance. The machine shall be so adjusted that the major load will be fully applied in from 6 to 8 seconds as a longer time will give an erroneous result due to "creeping" of some materials. **Procedure.**

43. The report shall include the following: **Report.**

(*a*) The Rockwell hardness number read on the black scale, the major load and the diameter of the penetrator;

(*b*) The total thickness of the specimen;

(*c*) The number of pieces in a specimen and their average thickness, and

(*d*) The room temperature.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 967 (1933); also 1934 Book of A.S.T.M. Tentative Standards, p. 1109.

TENTATIVE METHODS OF TESTING LAMINATED TUBES USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 348 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1932; Revised, 1932, 1934.

Scope. 1. These methods are intended to apply to laminated tubes to be used as electrical insulation.

TENSILE STRENGTH

Apparatus. 2. Any standard type of testing machine may be used provided it is accurate to within 1 per cent of the lowest load for which it is used. Jaws which tighten under load, such as wedge grip jaws, shall be used with the specimen properly aligned. Steel or brass plugs, 3½ in. in length and of a suitable diameter with edges rounded to $\frac{1}{16}$-in. radius will be required. The plugs shall fit the specimen to within 0.010 in. They can be conveniently located in the tube by separating and supporting them on a metal rod, the lower end of which is screwed into the lower plug, and the upper end rests in a loose socket as shown in Fig. 1.

Specimens. 3. Test specimens shall be 12 in. in length. Where the wall thickness of tubing is ⅛ in. or over, a lathe cut 1 in. in width and $\frac{1}{32}$ in. in depth, with corner rounded to a radius of 3 in. shall be made around the tube at the center.

Procedure. 4. Five specimens shall be tested. The inside and outside diameters shall be measured at the groove and the cross-section area shall be calculated from these dimensions. The metal plugs shall be assembled with the tube as shown in Fig. 1. This assembly shall then be grasped in the V-notched jaws of the testing machine.

Speed of Testing Machine. 5. The cross-head speed of the testing machine shall be such that the load can be accurately weighed but shall not exceed 0.05 in. per minute when the machine is running idle.

Report. 6. The report shall include the following:

(*a*) The inside diameter of the specimen.

(*b*) The outside diameter of the specimen.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

(*c*) The outside diameter of the reduced section, if a groove was used.

(*d*) The full wall thickness of the specimen.

(*e*) The net area of the test section.

(*f*) The breaking load of each specimen in pounds or kilograms.

(*g*) The tensile strength of each specimen in pounds per square inch or kilograms per square centimeter.

(*h*) The room temperature.

COMPRESSIVE STRENGTH

Apparatus. 7. Any standard type of testing machine may be used provided it is accurate to within 1 per cent of the lowest load for which it is used. One end of the specimen shall bear upon an accurately centered spherical bearing block, located whenever practicable at the top. The metal bearing plates shall be directly in contact with the ends of the test specimen.

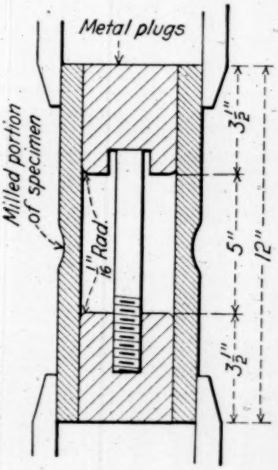


FIG. 1.—Metal Plugs Used for Tension Test, Showing Location of Plugs in Test Specimen.

Specimens. 8. Samples shall be tested as-received in specimen lengths of 1 in. Care shall be taken in cutting the specimens for the axial test to have the ends of the specimens cut accurately at right angles to the axis of the tube. Specimens which are not cut squarely are likely to give low results on test.

Procedure. 9. Five specimens shall be tested axially, with the load applied perpendicular to the faces or ends of the specimen, and five specimens shall be tested diametrically, with the load applied perpendicular to he tangent at point of application.

Report. 10. The report shall include the following:

(*a*) The inside and outside diameters of the specimen.

(*b*) The wall thickness of the specimen.

(*c*) The direction of application of the load.

(*d*) The load on each specimen at the first sign of rupture, in pounds or kilograms.

(*e*) The ultimate compressive strength in pounds per square inch or kilograms per square centimeter, calculated from the data obtained on the application of the load perpendicular to the face of the specimen.

WATER ABSORPTION

Specimens. 11. (*a*) Specimens of tubes having inside diameters less than 3 in. shall be the full section of the tube and 1 in. in length. For larger tubes, a rectangular specimen shall be cut 3 in. in length in the circumferential direction of the tube and 1 in. in width lengthwise of the tube.

(*b*) The specimens shall be sawed from the sample so as to have smooth edges free from cracks. The cut edges shall be finished with No. 0 or finer sandpaper or emery cloth. Sawing and sandpapering operations shall be slow enough so that the material is not heated appreciably. The specimens shall be rinsed with gasoline to remove any oil from the machining operation, wiped with a dry cloth and allowed to stand in air for 2 hours to remove the gasoline.

Procedure. 12. (*a*) The specimen shall be dried in an oven for 1 hour at 105 to 110 C. and cooled in a desiccator. For materials which will not withstand this temperature the drying shall be omitted.

(*b*) The dried specimen shall be immersed in distilled water maintained at a temperature of 25 C. ± 2 C. (77 F. ± 3.6 F.) throughout the test. At the end of 2 hours, the specimen shall be removed from the water, the surface water wiped off with a dry cloth, weighed immediately, and then replaced in the water. If the specimen is $\frac{1}{16}$ in. in thickness or less it shall be weighed in a weighing bottle. The difference between the weight of the wet specimen and that of the dry specimen shall be recorded as the weight of water absorbed in 2 hours. The percentage of water absorbed shall be calculated on the weight of the dry specimen.

(*c*) After 24 hours' immersion the specimen shall again be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed. The difference between the weight of the specimen after 24 hours' immersion and the weight of the dry specimen shall be recorded as the water absorbed in 24 hours. The percentage of water absorbed shall be calculated on the weight of the dry specimen. If the individual 24-hour absorptions differ by more than 10 per cent from the average absorption of the two specimens, the test shall be repeated.

Report.

13. The report shall include the following:
(*a*) The inside and outside diameter of the specimen.
(*b*) The wall thickness of the specimen.
(*c*) The percentage of water absorbed in 2 hours and in 24 hours.

DIELECTRIC STRENGTH

Apparatus.

14. A high-voltage transformer as described in Section 2 of the Tentative Methods of Testing Sheet, Tape and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 - 34 T) of the American Society for Testing Materials,[1] shall be used. The inner electrode shall consist of a brass rod 3 in. in length with edges rounded to $\frac{1}{4}$-in. radius. This should fit snugly inside of the tube to be tested. It shall be fitted with a binding post on one end. The outer electrode shall consist of a strip of metal foil $2\frac{1}{2}$ in. in width and long enough to extend around the circumference of the tube.

Specimens.

15. Specimens for the dielectric strength test shall be 12 in. in length.

Procedure.

16. Five specimens shall be tested. The brass rod inner electrode shall be placed directly in the center of the tube and for the outside electrode a strip of metal foil $2\frac{1}{2}$ in. in width shall be wrapped around the tube. The tubes shall be immersed in oil and all tests shall be made at room temperature. Short-time and step-by-step tests shall be made in accordance with the Tentative Methods of Testing Sheet, Tape and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 - 34 T) of the American Society for Testing Materials.[1]

REPORT

Report.

17. The report shall include the following:
(*a*) The inside and outside diameter of the specimen.
(*b*) The wall thickness of the specimen.
(*c*) The breakdown voltage of each specimen.
(*d*) The average breakdown voltage of all specimens.
(*e*) The average dielectric strength in volts per mil.

DENSITY

Specimens.

18. Two specimens shall be tested. Any suitable size specimen may be used. The specimen 1 in. in length used for the water absorption test, Section 11, will be found convenient.

---

[1] See p. 982.

Procedure. 19. Any suitable weight-difference apparatus for making readings in water and air, or the weight and dimensions of the specimen may be used as a basis for calculating the density.

Report. 20. The report shall express the density in c. g. s. units.

PHASE DIFFERENCE (POWER FACTOR) AND DIELECTRIC CONSTANT

Phase Difference and Dielectric Constant. 21. The phase difference and dielectric constant shall be determined in accordance with the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant (A.S.T.M. Designation: D 150 – 34 T) of the American Society for Testing Materials.[1]

---

[1] See p. 1029.

TENTATIVE METHODS OF TEST
FOR
THICKNESS OF SOLID ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 374 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1933; Revised, 1934.

Scope

1. (*a*) These methods are intended to determine the thickness of solid insulating materials, except rubber insulating tape which should be tested in accordance with Tentative Specifications and Tests for Rubber Insulating Tape (A.S.T.M. Designation: D 119 - 34 T) of the American Society for Testing Materials,[2] and friction tape for electrical purposes which should be tested in accordance with the Tentative Specifications and Tests for Friction Tape for General Use for Electrical Purposes (A.S.T.M. Designation: D 69 - 34 T) of the American Society for Testing Materials.[3]

Alternative Procedures, Methods A and B

(*b*) Two alternative procedures, Methods A and B, are described. In Method A the use of an adjusted ratchet micrometer and a definite manipulative procedure controls the pressure exerted on the specimen. In Method B a micrometer without ratchet is used and pressure on the specimen is controlled by stopping closure of the micrometer when resistance to movement of the specimen between the instrument faces is first observed.

Precision of Methods

(*c*) Method B is used generally for routine measurements. Method A, which may also be used for routine measurements, is preferable in cases of dispute. The precisions of the two methods are as follows:

For unyielding materials, such as porcelain and laminated or molded phenolic materials, the maximum error of either method is of the order of 0.5 mil or less.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] See p. 1145.

[3] See p. 1139.

For compressible materials, such as paper, fabric or leather, the maximum error of Method A is of the order of 0.5 mil. By applying the proper technique, Method B will give an accuracy of the order of 0.5 mil for the usual thicknesses of resilient materials encountered in the trade, except that for materials which are very compressible, the error may be somewhat greater.

Method A

Apparatus

2. The instrument used for determining thickness by Method A shall be a 1-in. machinist's type micrometer constructed with a vernier reading to 0.1 mil (0.0001 in.) and with a ratchet mechanism having a coil spring, pin-type pawl, and having anvil and spindle surfaces 0.250 in. ± 0.001 in. in diameter. The instrument shall conform to the requirements for flatness and parallelism of micrometer surfaces, zero reading, wear of micrometer screw, micrometer screw error tolerances and ratchet pressure specified in Section 6 (*d*), (*e*), (*f*), (*g*), (*h*) and (*i*). The micrometer shall be tested and calibrated periodically for conformity to these requirements.

Procedure

3. Before starting measurements of thickness the micrometer shall be closed on the specimen at a location outside the area to be measured. The micrometer shall then be opened not more than 4 or 5 mils (0.004 or 0.005 in.) and then moved into the area selected for measurement. Using the ratchet, the micrometer surfaces shall be closed so slowly on the specimen that the mil scale divisions may be easily counted as they move past the reference mark, or at a rate of about 2 mils (0.002 in.) per second. The closing motion shall be continued at the same rate until the ratchet has clicked three times, and then the thickness shall be read by means of the vernier.

In moving from one measurement location to another this operation shall be repeated, never opening the micrometer more than 4 or 5 mils (0.004 or 0.005 in.) more than the specimen thickness.

Method B

Apparatus

4. The instrument used for determining the thickness by Method B shall be a 1-in. machinist's type micrometer equipped with vernier reading to 0.1 mil (0.001 in.) but without a ratchet device and shall have anvil and spindle surfaces 0.250 in. ± 0.001 in. in diameter. The instrument shall conform to the requirements for flatness and parallelism of micrometer surfaces, zero reading, and micrometer

screw error tolerances specified in Section 6 (*d*), (*e*), (*f*) and (*h*). The micrometer shall be tested and calibrated periodically for conformity to these requirements.

Procedure

5. In the determination of thickness the micrometer specified in Section 4 shall be slowly closed on the specimen until contact is made, without appreciable distortion of the specimen. The criterion of contact is the initial development of frictional resistance to movement of the specimen between the micrometer surfaces. The thickness shall then be read by means of the vernier.

In moving from one measurement location to another this operation shall be repeated, never opening the micrometer more than 4 or 5 mils (0.004 or 0.005 in.) more than the specimen thickness.

MICROMETER REQUIREMENTS

Cleaning Micrometer Surfaces

6. (*a*) Before and during instrument calibration and thickness measurements, the micrometer surfaces shall be maintained in a clean condition by lightly closing them on a clean sheet of bond paper and moving the paper between the surfaces.

Calibrating Method A Micrometer

(*b*) The manipulative procedure for calibrating controlled pressure instruments used in Method A, shall be in accordance with the following:

The micrometer shall be closed on the gage or calibrating device and then opened 4 or 5 mils (0.004 or 0.005 in.). Using the ratchet, the micrometer shall be again closed so slowly on the calibrating device that the mil scale divisions may be easily counted as they move past the reference mark, or at the rate of about 2 mils (0.002 in.) per second. The closing motion shall be continued at the same rate until the ratchet has clicked three times, when the reading shall be taken.

Calibrating Method B Micrometer

(*c*) The manipulative procedure for calibrating instruments used in Method B shall be in accordance with the following:

The micrometer shall be slowly closed on the gage or calibrating device until contact of the surfaces and gage is made. The criterion of contact is the initial development of frictional resistance to movement of the gage device between the micrometer surfaces.

Flatness of Micrometer Surfaces

(*d*) The anvil and spindle surfaces of the micrometer shall be flat to within 0.00005 in. The flatness may be determined by use of an optical flat, as follows:

After cleaning the surfaces of the flat and the micrometer (Paragraph (*a*)) the latter shall be closed on the flat as described in Paragraph (*b*) or (*c*). When illuminated by diffused daylight, interference bands are formed between the surfaces of the flat and those of the micrometer. The location, shape and number of these bands indicates the deviation from flatness in increments of half the average of the wave lengths of white light, which is taken as 0.00001 in.

A *flat surface* forms straight, parallel and equidistant fringes.

A *grooved surface* forms straight parallel fringes at unequal intervals. The estimated maximum displacement of any line from its normal position, where all lines would be equidistant, is a measure of deviation from flatness.

A *symmetrical concave or convex surface* forms concentric circular fringes, and their number is a measure of deviation from flatness.

An *unsymmetrical concave or convex surface* forms a series of curved fringes, cutting the periphery of the micrometer surface. The number of fringes cut by a straight line connecting the termini of any fringe is a measure of the deviation from flatness.

Parallelism of Micrometer Surfaces

(*e*) The anvil and spindle surfaces of the micrometer shall be parallel to each other to within 0.0001 in. when tested with a pair of screw-thread-pitch wires whose diameters, accurate to 0.00002 in., differ by an amount approximately equal to the axial movement of the spindle when rotated through 180 deg. (12.5 mils in the 1-in. micrometer). The micrometer shall be closed on the wire according to the procedure described in Paragraph (*b*) or (*c*). Observations, made with either wire placed at any location between the surfaces shall show differences of less than 0.0001 in.

Zero Reading

(*f*) The position of the anvil shall be such that a zero reading is obtained when the micrometer is closed on the anvil as described in Paragraph (*b*) or (*c*). Ten trials shall give ten readings of zero.

Wear of Micrometer Screw

(*g*) The device for compensating for wear of the micrometer screw shall be adjusted so that the spindle has no perceptible lateral or longitudinal looseness and yet may be rotated with a torque load of not more than $\frac{1}{4}$ in.-oz.

Micrometer Screw Error

(*h*) The micrometer screw error, after zero adjustment is made, shall be checked at 2, 5, and 10 mils, and at intervals of 100 mils over the remaining graduated scale. For checks up to and including a thickness of 10 mils, selected gage blades the thicknesses of which are known to ±0.00002 in. shall be used. Checks at values greater than 10 mils shall be made with standard gage blocks. Three times the standard deviation for ten readings at each setting shall not exceed 0.1 mil (0.0001 in.). Manipulation of the instrument in these checks shall be in accordance with Paragraph (*b*) or (*c*).

Ratchet Pressure

(*i*) The ratchet shall be so adjusted that a pressure of not more than 27 nor less than 23 lb. per sq. in. is developed when the spindle surface is contacted with a polished steel surface as described in Paragraph (*b*).

TENTATIVE METHODS OF TESTING VARNISHED CLOTHS AND VARNISHED CLOTH TAPES USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 295 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1928; REVISED, 1929, 1932, 1933, 1934.

Scope

1. These methods are intended to apply to varnished cloths and varnished cloth tapes to be used as electrical insulation and are directly applicable to both the "straight-cut" and "bias-cut" materials, unless otherwise stated in the method.

SAMPLING

Selecting Rolls

2. (*a*) Shipments of varnished cloth and varnished cloth tapes shall be sampled as specified in Paragraphs (*b*) and (*c*). The rolls or pads shall be selected in such a manner as to be representative of the shipment.

(*b*) *Cloth.*—One roll shall be selected from each ten rolls in a shipment of full-width varnished cloth. The minimum number of rolls selected from any shipment shall be two.

(*c*) *Tape.*—At least one roll or pad shall be selected from each 1000 rolls or pads in a shipment of varnished cloth tape. The minimum number of rolls or pads selected from any shipment shall be ten.

Selecting Samples

3. (*a*) Except for tape shipped packed in oil, not less than two turns of cloth or six turns of tape from each roll or pad selected for sampling shall be torn off and discarded before the samples are selected. The number of samples required for purposes of test shall then be cut across the entire width of each roll or pad. The length of the samples shall not be less than 91.44 cm. (36 in.) for straight-cut material; from seam to seam for sewed bias-cut material; and from jointed-selvage to jointed-selvage for seamless bias-cut material.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

NOTE 1.—Specimens of bias-cut materials cut from the above samples shall exclude seams and jointed-selvages from the test areas.

NOTE 2.—If it is desired to test the seams or jointed-selvages for tensile breaking strength, additional specimens will have to be cut so that the seams or jointed-selvages are in the center of the specimens.

(*b*) From shipments such as sheets of cloth or strips of tape, the samples shall be representative of the shipment and shall be taken in accordance with Paragraph (*a*).

CONDITIONING

Conditioning

4. (*a*) The roll of cloth or tape from which specimens are to be cut shall be conditioned for a minimum of 2 hr. at a room temperature between the limits of 20 to 30 C., no humidity control.

(*b*) Specimens for tensile breaking strength, elongation, and dielectric strength "as received" shall be removed from the roll as required and tested immediately.

(*c*) If the room humidity is above 65 per cent, the roll of tape shall be kept in a cabinet whose relative humidity is maintained between 60 to 65 per cent.

(*d*) In the event of dispute, the test specimens shall be conditioned for 48 hr. at a temperature between 20 to 30 C. and at a relative humidity between 60 to 65 per cent.

THICKNESS

Apparatus

5. The thickness shall be measured in accordance with Method B of the Tentative Methods of Test for Thickness of Solid Electrical Insulation (A.S.T.M. Designation: D 374 - 34 T) of the American Society for Testing Materials.[1]

Specimens

6. Specimens for test shall consist of samples selected in accordance with Section 3.

Procedure

7. In making thickness measurements, only one layer of material shall be used.

Number of Measurements

8. (*a*) In the case of cloths, ten measurements equally spaced across the width of the specimen shall be taken and the thickness of the cloth shall be the average of the ten measurements.

---

[1] See p. 1069.

(*b*) In the case of tapes, unless otherwise specified, ten measurements equally spaced along the length of each specimen shall be taken and the thickness of the tape shall be the average of the ten measurements.

NOTE.—The average thickness, as obtained in Section 15 for the dielectric strength test, may be conveniently used instead of the separate test described above.

Report

9. The report shall include the average, maximum, and minimum thicknesses in inches.

TENSILE BREAKING STRENGTH

Apparatus

10. (*a*) A testing machine[1] of the dead-weight pendulum type shall be used. The machine shall preferably be power driven.

(*b*) The capacity of the machine shall not exceed 113 kg. (250 lb.).

(*c*) The machine shall be graduated to read 1 lb. or 1 kg. or less per scale division for testing specimens breaking at 22.7 kg. (50 lb.) or over, and to 0.5 lb. or 0.5 kg. or less for testing specimens breaking under 22.7 kg. (50 lb.).

Test Specimens

11. Specimens cut from the full width cloth or from tapes over 2.54 cm. (1 in.) in width shall be 2.54 cm. (1 in.) in width and not less than 35.54 cm. (14 in.) in length. For tape having a nominal width of 2.54 cm. (1 in.) or under the specimens shall be of the original width and shall be not less than 35.54 cm. (14 in.) in length.

NOTE.—If it is desired to test the seams or jointed-selvages of bias-cut materials for tensile breaking strength, specimens obtained as described in Note 2 to Section 3 (*a*) shall be clamped in the testing machine so that the seams or jointed-selvages are midway between the two jaws. When testing, all readings obtained when the specimen breaks away from the seam or jointed-selvage shall be rejected.

Number of Specimens

12. (*a*) In the case of straight-cut cloths, ten specimens shall be cut in the direction of the warp threads and ten in the direction of the filling threads from samples selected in accordance with Section 3.

(*b*) In the case of bias-cut cloths, ten specimens shall be cut in the direction of the length from samples selected in accordance with Section 3.

(*c*) In the case of tapes, one specimen shall be cut from each roll selected in accordance with Section 2 (*c*).

---

[1] This apparatus is the same as that used for the testing of paper and described in Section 12 of the Tentative Methods of Testing Untreated Paper Used in Electrical Insulation (A.S.T.M. Designation: D 202 - 34 T), see p. 1009.

Procedure

13. (*a*) The ratio of the clearance distance between jaws to the width of the specimen shall not be less than 5 to 1 nor more than 10 to 1.

(*b*) The rate of travel of the movable jaw shall be constant and preferably 30.5 cm. (12 in.) per minute, but it may be within the limits of 28 cm. (11 in.) and 33 cm. (13 in.) per minute provided it is constant.

(*c*) All readings obtained when the specimen breaks at or in the jaws shall be rejected.

Report

14. (*a*) The tensile breaking strength of a roll shall be the average of the breaking loads of all the specimens from the roll. The report shall include the average, maximum, and minimum breaking loads in kilograms or pounds together with the width of the specimens and the nominal thickness.

(*b*) In the case of straight-cut cloths, the tensile breaking strength of the warp threads and the filling threads shall be reported separately.

DIELECTRIC STRENGTH

Method

15. (*a*) The dielectric strength shall be determined in accordance with the Tentative Methods of Testing Sheet, Tape, and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 - 34 T) of the American Society for Testing Materials,[1] except that the voltage on the specimen shall in all cases be increased at the uniform rate of 0.5 kv. per second up to breakdown.

(*b*) Dielectric strength tests may be applied to specimens of the material as received and on specimens from the elongation and resistance to oil tests.

Specimens

16. (*a*) In the case of cloths, a specimen at least 10.16 cm. (4 in.) in width shall be cut diagonally from corner to corner from a sample selected in accordance with Section 3.

(*b*) In the case of tapes, the specimens shall be samples selected in accordance with Section 3.

ELONGATION

(*In the Case of Bias-Cut Material*)

Scope

17. This method is intended to determine the effect of mechanical tension on bias-cut varnished cloths and tapes. This test is not applicable to tapes of less than 1.27 cm. (0.5 in.) in nominal width.

---

[1] See p. 982.

Apparatus

18. The apparatus required for the test shall consist of a pair of clamps for gripping the ends of the specimen. The clamps shall not be less than 5.08 cm. (2.0 in.) in width and one shall be provided with means for attaching to a fixed support and the other with means for affixing suspended weights. See Fig. 1 for suggested form of clamp.

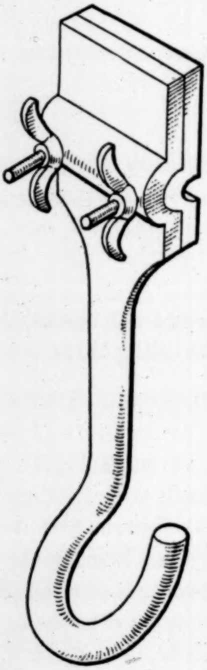


FIG. 1.—Clamp for Elongation Test.

Specimens

19. (*a*) In the case of bias-cut cloths, specimens shall be cut in the direction of the length from the samples selected in accordance with Section 3. They shall not exceed 3.81 cm. (1.5 in.) in width and shall be at least 91.44 cm. (36 in.) in length.

(*b*) In the case of bias-cut tapes, specimens shall be samples selected in accordance with Section 3 and they shall not exceed 3.81 cm. (1.5 in.) in width. Tapes of greater width than this shall be cut to 3.81 cm. (1.5 in.) or less before testing.

NOTE.—Strips of "Scotch tape" make a satisfactory method for marking the gage length on the elongation test specimens.

Elongation

20. A gage length of 50 cm. shall be marked on the test specimen and the specimen shall be fastened between two suitable clamps so that the gage length is centrally located between the clamps. The clearance distance between each gage line and the adjacent clamp shall be not less than 10 cm.

The test specimen shall be weighted with a specified load, M, (including the weight of the clamp) and at the end of 35 minutes the distance, L, between gage lines shall be measured and the load then removed.

Calculation

21. The percentage elongation is defined by the following formula:

$$\text{Elongation, per cent} = \frac{L - 50}{50} \times 100$$

in which L is in centimeters.

Dielectric Strength

22. After at least 20 min., but not more than 1 hr., following the removal of the load, five puncture voltages shall be taken within the gage length of the specimen in accordance with Section 15, using only Method A of the Tentative Methods D 149 – 34 T.[1] The dielectric strength shall be calculated on the basis of the average thickness of the specimen determined immediately before the dielectric breakdown test.

Report

23. The report shall include the following:

(*a*) the load in pounds per inch width of tape;

(*b*) the percentage elongation;

(*c*) the average dielectric strength in volts per mil after elongation; and

(*d*) the temperature of the room during the elongation test.

RESISTANCE TO OIL

Scope

24. This method is intended to determine the effect of oil on the varnish film and dielectric strength of the cloths or tapes.

Specimens

25. One specimen 30.48 cm. (12.0 in.) in length and not exceeding 3.81 cm. (1.5 in.) in width shall be cut from each of the rolls selected in accordance with Section 2.

---

[1] See p. 982.

Procedure

26. The specimens shall be immersed for 15 min. in a specified oil maintained at a temperature of from 97 to 103 C. At the end of this time, the specimens shall be removed from the oil, allowed to cool for at least 30 min. to room temperature and any excess oil removed by placing between blotters without any sliding.

Examination

27. The varnish film shall be examined for disintegration in the oil and flaking either in the oil or on the blotter. Disintegration in the oil may be detected by examination of the used oil for turbidness.

NOTE.—The oil may be considered turbid if a sample of used oil filtered through filter paper is distinctly less transparent than an unfiltered sample of the unused oil when the two samples, in identical containers, are held in front of a diffused light. Flaking along the cut edges of tapes shall not be considered as disintegration of the varnish film.

Dielectric Strength

28. Specimens which have been allowed to cool at least 30 min. may be tested for dielectric strength any time within a period of 4 hr. after removal from the oil. Five puncturing voltages shall be taken on the specimens in accordance with Section 15, using only Method A of the Tentative Methods D 149 – 34 T.[1] The dielectric strength shall be calculated on the basis of the average thickness of the specimen determined immediately before the dielectric breakdown test.

Report

29. The report shall include the following:

(*a*) The type of oils used (preferably including the flash point determined in accordance with the Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92) of the American Society for Testing Materials).[2]

(*b*) The temperature of the oils.

(*c*) Results of the physical examination of the film (Section 27).

(*d*) The percentage increase in average thickness due to oil tests.

(*e*) The average dielectric strength in volts per mil after the oil tests.

---

[1] See p. 982.

[2] 1933 Book of A.S.T.M. Standards, Part II, p. 800.

WEIGHT

Weight

30. Specimens of sufficient size to weigh not less than 5 g. (0.18 oz.) shall be accurately weighed on an analytical balance and the weight shall be reported on some commercial unit basis such as, the weight per square yard, the weight per gross yard per 1 in. in width or the weight per roll.

THREADS PER INCH

Count

31. The count or threads per inch of the varnished cloth or varnished cloth tape shall be determined separately on the warp and filling by counting a space of not less than 1 in. (2.54 cm.) in at least five different places in the sample strip (or strips). The average of the five determinations shall be the count.

Report

32. The results of the warp count and the filling count shall be reported separately as threads per inch.

NOTE 1.—The warp threads in straight-cut materials are the threads which are parallel with the length dimension, while in bias-cut materials the warp threads are parallel with the seams and jointed selvages.

NOTE 2.—Before counting black, varnished materials it will be necessary to remove the varnish film with a knife blade or other suitable instrument. Liquid varnish removers are unsuitable for this purpose as they cause a swelling of the fibers and a shrinkage of cloth with a consequent increase in threads per inch; therefore, the films must be removed mechanically.

TENTATIVE METHODS OF TESTING VARNISHES USED FOR ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 115 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1921; REVISED, 1922, 1923, 1924, 1925, 1926, 1928, 1929, 1930, 1931, 1934.

Scope.

1. These tests are intended for varnishes which are applied by brushing, dipping or spraying, and are primarily for the purpose of providing electrical insulation.

SPECIFIC GRAVITY

Specific Gravity.

2. The specific gravity shall be measured with a pycnometer, Westphal balance or with a hydrometer so graduated that the specific gravity can be determined to 0.001. The temperature of the varnish shall be not less than 18° C. (64.4° F.) nor more than 22° C. (71.6° F.) and corrected to 20° C. (68° F.) by applying a correction of 0.0007 per 1° C. (0.0004 per 1° F.).

VISCOSITY

Viscosity.

3. (*a*) The viscosity shall be determined at 20° C. (68° F.) and the results shall be stated in terms of absolute viscosity—poise[2] or centipoise (centipoise = 0.01 poise).

(*b*) Viscosimeters used in this test shall be calibrated with oils certified as to viscosity in absolute units by the National Bureau of Standards. A calibration curve having viscosities in absolute units as ordinates and instrument readings as abscissas and covering the range of viscosities to be measured, shall be used.

NOTE.—A description of the MacMichael viscosimeter as remodeled and improved for varnish testing together with directions for its calibration in absolute units appears in Appendix I.

FLASH POINT

Procedure for Flash Point.

4. The flash point shall be determined in accordance with the Standard Method of Test for Flash Point of Volatile Flammable

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-9 on Electrical Insulating Materials.

[2] **The absolute viscosity of a material or its viscosity in absolute units (c.g.s., poises) has been defined as the force in dynes required to move, at a velocity of 1 cm. per second, one surface having an area of 1 sq. cm. past another parallel like surface 1 cm. away, overcoming the resistance to shear of the material filling the space between.**

Liquids (A.S.T.M. Designation: D 56) of the American Society for Testing Materials.[1]

TIME OF DRYING

Test Specimen.

5. (*a*) Specimens for this test shall be pieces of thoroughly cleaned, smooth sheet copper or brass about 4 cm. (1.57 in.) wide and 20 cm. (7.88 in.) long and about 0.127 mm. (0.005 in.) thick.

(*b*) The specimen shall be dipped once in the varnish at a room temperature of approximately 20° C. (68° F.) and withdrawn slowly and uniformly (about 38 cm. (15 in.) per minute). The consistency of the varnish shall be first so adjusted by trial that, when dry as determined in accordance with Section 7, the average thickness of the film of varnish on each side of the metal shall be between 0.022 and 0.026 mm. (0.0009 and 0.001 in.) Care shall be taken before dipping the specimens that the varnish has stood in the dipping tank for a sufficient length of time to be free from air bubbles.

Procedure.

6. (*a*) Specimens of air-drying varnish shall be dried in dust-free air at a room temperature of approximately 20° C. (68° F.).

(*b*) In the case of baking varnishes, six specimens shall be dipped and allowed to drain at a room temperature of approximately 20° C. (68° F.) until the varnish is set as indicated when the impression left on the surface by pressing lightly thereon with a finger at a point approximately 2 in. from the bottom will not become obliterated by further flow of the material. They are then to be dried in dust-free air in an oven at 105 to 110° C. (221 to 230° F.). At the end of the first 30 minutes, and again at the end of each 10-minute period thereafter, one specimen shall be taken from the oven and examined. In the case of slow-drying varnishes, this 10-minute period may be lengthened at the discretion of the operator.

NOTE.—The size of oven and the amount of ventilation have a considerable effect on the drying time of varnishes. For this reason the analytical type of electrically-heated oven should be used.

Time of Drying.

7. The varnish shall be considered dry when a piece of kraft paper 38 mm. (1.49 in.) in width and 152 mm. (6 in.) in length and approximately 0.063 mm. (0.0025 in.) in thickness does not adhere to the varnish when it is pressed on the surface of the varnish for one minute by a cylindrical 1-lb. weight, 1 in. in diameter. The kraft paper shall be applied in the vicinity of the center of the specimen and at right angles to it. The test shall be made at a temperature of approximately 20° C. (68° F.).

NOTE.—Certain types of varnishes dry with what is commonly known as a "tack"; but these types are rare. However, when testing them for drying time, it will be found that the kraft paper adheres to the varnish film and offers a certain amount of resistance to removal. On continued drying, the resistance to removal reaches constancy and is not changed by further drying. Therefore, the drying time is reported as the number of hours required to first reach constancy and the varnish should be reported as drying with a "tack."

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 663.

DIELECTRIC STRENGTH TEST[1]

Scope.

8. (*a*) This test is intended to determine the suitability of an insulating varnish for use in certain electrical applications by taking the dielectric strength test under different conditions of temperature and after immersion in water. The test provides for the determination of dielectric strength under the following conditions:

(*1*) At room temperature (approximately 20° C.) in air.

(*2*) At 75° C. in air.

(*3*) At room temperature after immersion in water of approximately 20° C. (68° F.) for a period of 24 hours.

NOTE.—Dielectric strength determinations may also be made at room temperature and at 75° C. in oil. With this exception the procedure for test is the same as outlined here. If tests are made in oil this fact must be definitely reported with the results.

(*b*) Much more information about a varnish can be obtained by making the test under all three conditions than by making it under only one condition. The relation which the dielectric strength tests for a given varnish show to one another, is of quite as much significance as the values for the different tests considered separately.

Test Specimens.

9. (*a*) Specimens for the dielectric strength test shall be prepared by dipping pieces of kraft paper about 20 cm. (7.88 in.) square and about 0.076 mm. (0.003 in.) in thickness into the varnish which shall be at the consistency specified in Section 5 (*b*).

NOTE.—The paper used shall be that which is commercially known as No. 1 sulfate kraft. The surface of the paper shall be smooth, free from pimples or lumps and reasonably free from hairy fibers. The paper shall also be free from conducting particles, slime spots, creases, cuts, specks or other "paper defects."

(*b*) Each specimen shall be dipped twice, as specified in Section 5 (*b*), once in each direction, in order to give a more uniform thickness of coating. The specimen shall be dried after each dip in the same vertical position in which it was dipped.

(*c*) Specimens of air-drying varnish shall be dried in dust-free air after each dip at a room temperature of approximately 20° C. (68° F.) for a period six times that determined in accordance with Section 7.

---

[1] This test is relative only, but it gives more uniform results than those obtained with a copper base. See Appendix II for a procedure for determining the dielectric strength on a copper base, p. 1100.

(*d*) Specimens of baking varnish shall be drained and then baked in dust-free air at a temperature of 105 to 110° C. (221 to 230° F.) after each dip for a period three times that determined in accordance with Section 7.

(*e*) The final thickness of the specimen shall be 0.152 mm. (0.006 in.) to within ± 15 per cent.

Procedure.

10. (*a*) The dielectric strength of the specimen shall be determined by applying alternating potential to two circular metal disks, 5.08 cm. (2.0 in.) in diameter and with edges rounded to a radius of 0.64 cm. (0.25 in.) which are placed in contact with the two sides of the specimen directly opposite each other and under a pressure of approximately 0.5 kg. (1.1 lb.). Starting at zero, the voltage shall be increased at a rate of approximately 0.5 kv. per second. The electrodes shall be polished and cleaned after each puncture. As the temperature of the electrodes increases after a number of tests, it is advisable to change the electrodes after every twenty punctures. Ten such punctures are to be made at various points selected at random on each specimen. After testing, the thickness of the specimen shall be determined by making five measurements on a strip cut diagonally across the specimen. The measurements shall be equally spaced along the strip except in the case of a measurement being too close to a point of puncture. The average of the five measurements shall be considered as the thickness of the specimen.

(*b*) The frequency of the test potential shall be not greater than 100 cycles per second, and each part of the testing apparatus shall have a continuous rating of not less than 2 kva. (preferably larger). The wave form shall be a sine curve as defined by the American Institute of Electrical Engineers,[1] and the voltage shall be measured by methods approved by the same organization.

(*c*) The voltage may be controlled by any approved method which does not distort the wave form beyond the limits prescribed above and which does not subdivide the voltage in steps greater than 100 volts. The apparatus shall comply with the standards of the American Institute of Electrical Engineers.[1]

Test Conditions.

11. The dielectric strength shall be determined under the following conditions:

(*a*) At room temperature (approximately 20° C.) in air.

(*b*) At 75° C. in air.

NOTE.—The tests at 75° C. shall be made in air in an analytical type of electrically-heated oven. The electrodes shall be at oven temperature before the test is started. Tests should be started 15 minutes after the specimen has been introduced into the oven and placed between the electrodes and completed before 15 minutes additional have elapsed.

---

[1] Standards of the American Institute of Electrical Engineers.

(*c*) At room temperature on specimens which shall have been immersed in water at a room temperature of approximately 20° C. (68° F.) for a period of 24 hours.

NOTE 1.—In testing specimens after immersion in water, only one specimen should be removed from the water at a time. The specimen after removal from the water should be carefully dried by placing between sheets of dry blotting paper and pressing down gently with the hand over the entire surface. If necessary, the blotting procedure should be repeated until the specimen is free from surface moisture. The specimen should then be tested immediately. If specimens are allowed to remain out of water for even a short time before testing, they dry out to a greater or less extent and the test is apt to be misleading.

NOTE 2.—Dielectric strength determinations may also be made at room temperature and at 75° C. in oil. With this exception the procedure for test is the same as outlined above. If tests are made in oil this fact must be definitely reported with the results.

Report. 12. In reporting the results for each of the three tests made as described in Section 11, the total voltage at puncture, the thickness of the specimen and the volts per mil of thickness shall be reported for each of the ten punctures together with the average, maximum and minimum values. In addition, the average dielectric strength in volts per mil of the test made at 75° C. and of the test made after water immersion shall be expressed as a percentage of that made at room temperature.

HEAT ENDURANCE TEST

Test Specimens. 13. (*a*) Specimens shall be prepared by dipping pieces of thoroughly cleaned, smooth sheet copper or sheet brass about 20 cm. (7.88 in.) in length, 3 cm. (1.18 in.) in width and 0.127 mm. (0.005 in.) in thickness, into the varnish. The consistency of the varnish shall previously be adjusted by trial so that, when dry as determined in accordance with Section 7, the average thickness of the film of varnish on each side of the metal shall be between 0.022 and 0.026 mm. (0.0009 and 0.001 in.).

(*b*) Each specimen shall be dipped in the varnish at room temperature of approximately 20° C. (68° F.) and withdrawn slowly and uniformly (about 38 cm. (15 in.) per minute). The varnish shall be allowed to dry in the air (if an air-drying varnish) or baked in an oven at 105 to 110° C. (221 to 230° F.) (if a baking varnish) until dry as determined in accordance with Section 7. As soon as the first coat of varnish is dry, and the specimen is at room temperature, it shall be dipped again in the varnish in the reverse direction so as to give a uniform thickness of coating. The second coat of varnish shall be allowed to dry in the same manner as the first coat. When the second coat of varnish is dry, the specimen shall be measured. The thickness of varnish on each side of the metal shall be between 0.044 and 0.052 mm. (0.00173 and 0.00205 in.).

14. (*a*) The specimens shall be placed in a uniformly-heated oven, in which the temperature is maintained at 105 to 110° C. (221 to 230° F.). A specimen shall be removed at the end of the first 24 hours and every 24 hours thereafter. **Procedure.**

NOTE.—Because of temperature variations between different levels in the oven. the specimen should be placed in the oven with the 8-in. dimension horizontal and the 1-in. dimension vertical. All specimens should be at the same level in the oven.

(*b*) Each specimen, after heating, shall be tested at room temperature of approximately 20° C. (68° F.) by bending it through 180 deg. around a rod 0.32 cm. (0.125 in.) in diameter.

15. The number of hours of baking of the specimen which first showed cracking of the varnish film shall be reported, together with the make and type number of the oven used. **Report.**

NOTE 1.—This size of oven and the amount of ventilation have a considerable effect on the heat endurance of varnish films. For this reason the analytical type of electrically-heated oven should be used.

NOTE 2.—The temperature of the oven should be held as closely as possible to the mean (107.5° C., 225.5° F.). A difference of 5° C., (9° F.) in this temperature range, when continuously maintained, has a very considerable effect (approximately 25 per cent) on the life test of a varnish.

NOTE 3.—As the "grain" of the copper influences the result of the test, the heat endurance test specimens should be prepared by cutting the copper strips parallel with the direction of rolling.

OIL PROOF TEST

16. (*a*) To test for the effect of oil, the specimens shall be prepared as prescribed in Section 13 (*a*). **Oil Test Specimen.**

(*b*) The specimens shall be dipped and dried as prescribed in Section 9 (*b*), (*c*) and (*d*).

17. The effect of oil on the varnish shall be determined by immersing the specimens in transformer oil at a temperature of 105 to 110° C. (221 to 230° F.) for 48 hours and noting the effect on the varnish as indicated, for example, by wiping with a piece of dry white cloth. **Procedure.**

NOTE.—Incipient disintegration of the surface of the varnish may sometimes be detected by examining the oil for turbidity. If a specimen of the used oil filtered through filter paper can be distinguished from an unfiltered sample of the used oil, when the two samples in identical containers are held in front of a diffused light, the oil is turbid.

DRAINING TEST

(ALSO KNOWN AS "WORKING VISCOSITY" TEST)

Test Specimen. 18. A strip of sheet copper or brass about 4 cm. (1.57 in.) wide, 35 cm. (13.78 in.) long, and 0.127 mm. (0.005 in.) thick, shall be immersed in the varnish at a room temperature of approximately 20° C. (58° F.) up to a line previously drawn across the strip 1 in. from the top. The sheet shall be withdrawn at a slow and uniform rate (about 38 cm. (15 in.) per minute), care being taken that the varnish is free from air bubbles. The specimen shall be permitted to drain thoroughly at room temperature while suspended in a vertical position. It shall then be dried or baked (according to the type of the varnish) until dry as determined in accordance with Section 7.

Measurements. 19. The thickness of the specimen in mils shall be measured at points 5.1 cm. (2 in.), 17.8 cm. (7 in.) and 30.5 cm. (12 in.), respectively, from the line to which the specimen was immersed.

Report. 20. The thickness of each film in mils at the three points specified in Section 19 shall be recorded. The difference between the thickness at the upper point (5.1 cm.) and that at the lower point (30.5 cm.) shall be taken as a measure of the variation in the film thickness caused by draining.

TEST FOR NON-VOLATILE MATTER BY WEIGHT

Procedure. 21. A portion of the sample shall be placed in a stoppered bottle or weighing pipette and weighed. About 1.5 g. of the sample shall be transferred to a weighed flat-bottom metal dish about 8 cm. (3.15 in.) in diameter, such as the cover of a friction-top tin can. The container shall again be weighed and the exact weight of the portion of the sample transferred to the weighed dish calculated by difference. The dish with its contents shall be heated for three hours in an oven maintained at 105 to 110° C. (221 to 230° F.). It shall then be weighed after cooling.

Non-Volatile Matter. 22. The ratio of the weight of the residue to the weight of the original sample expressed as a percentage shall be taken as the percentage of non-volatile matter by weight in the varnish.

TEST FOR VOLATILE MATTER BY VOLUME

Scope. 23. This test is intended to determine the volume percentage of volatile matter (solvent) in a varnish, and to afford a means of arriving at the volume composition of the varnish with respect to volatile (solvent) and non-volatile (base) constituents.

Procedure. 24. (*a*) About 100 ml. of the varnish shall be distilled in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials.[1] The distillation shall be "qualitative" instead of "quantitative" as given in Section 9 of the Standard Method D 86; that is, it is not necessary to record the volume of distillate recovered, or the temperature of the initial boiling point or end point.

(*b*) The distillation shall be continued until a suitable end point indicates that all the volatile matter (solvent) has been distilled off.

NOTE.—In the distillation of varnishes the end point differs with the various types and compositions. In all cases, however, the rate of distillation slows down as the end point is approached; and, when the end point is reached, acrolein (formed in the decomposition of the varnish base) is evolved and may be detected by its characteristic odor.

In addition to the evolution of acrolein, the following phenomena are suitable indicators of end point:

(1) When the end point of the solvent is considerably lower than the initial boiling point of the base, the end point of the distillation is indicated by the temperature reaching a maximum and then starting to fall consistently.

(2) When the end point of the solvent and the initial boiling point of the base are too close, or overlap, the above temperature drop does not occur. The end point of the distillation is then indicated by a sudden foaming up of the residual base in the distillation flask; or, if the distillation has been accompanied by foaming, the end point is indicated by a breaking of surface tension with a consequent cessation of foaming.

Specific Gravity.

25. The specific gravity of the volatile matter (solvent) recovered by distillation shall be determined in accordance with the procedure described in Section 2.

Volatile Matter by Weight.

26. The difference between 100 per cent and the percentage of non-volatile matter determined in Sections 21 and 22 shall be calculated and recorded as the percentage of volatile matter by weight.

Volatile Matter by Volume.

27. The percentage of volatile matter by volume shall be calculated from the formula:

$$x = \frac{AC}{B}$$

where

x = the percentage of volatile matter by volume;
A = the specific gravity of the original varnish, as determined in Section 2;
B = the specific gravity of the volatile matter (solvent) recovered by distillation, as determined in Section 25; and
C = the percentage of volatile matter by weight, as determined in Section 26.

Accuracy.

28. With proper care and attention to detail in making this test, differences occurring between different laboratories should not exceed

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 778.

2 per cent for varnishes containing solvents which have end points not over 235° C. (455° F.), and should not exceed 4 per cent when the end point of the solvent is as high as 307.2° C. (585° F.).

DIELECTRIC STRENGTH OF VARNISH IN THE LIQUID STATE

Scope. 29. The purpose of the dielectric strength test of varnish in the liquid state is to insure that the varnish is free from moisture and foreign matter such as might come from unclean shipping containers.

Apparatus. 30. The apparatus shall be as described in Section 14 of the Standard Methods of Testing Molded Materials Used for Electrical Insulation (A.S.T.M. Designation: D 48) of the American Society for Testing Materials.[1] The test cup for holding the sample of varnish shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by mineral oil and gasoline and non-absorbent so far as moisture, mineral oil and gasoline are concerned. The electrodes in the test cup between which the sample is tested shall be circular disks of polished brass or copper, 1 in. in diameter and having square edges. The electrodes shall be mounted in the test cup having their axes horizontal and coincident, with a gap of 0.1 in. between their adjacent faces, and with top of electrodes about 33 mm. (1¼ in.) below the top of the cup.

Procedure. 31. (*a*) The electrodes and the test cup shall be wiped clean with dry calendered tissue paper or with a clean dry chamois skin, and thoroughly rinsed with a suitable solvent such as dry benzol or redistilled carbon tetrachloride. The electrodes and test cup shall then be rinsed with some of the varnish to be tested.

(*b*) The spacing of electrodes shall be checked with a standard round gage having a diameter of 0.100 in. and the electrodes then locked in position. Care shall be taken not to touch the electrodes with the gage or in any other manner after cleaning the electrodes and cup, so as to avoid any possible contamination.

(*c*) The temperature of the varnish when tested shall be the same as that of the room, which should be between 20 and 30° C. (68 and 86° F.).

(*d*) The sample of the varnish shall be shaken so that it will be thoroughly mixed before filling the test cup, the shaking shall be done gently to avoid the formation of bubbles.

(*e*) The cup shall be filled with varnish to a height of not less than 20 mm. (0.787 in.) above the top of the electrodes.

(*f*) The varnish shall be allowed to remain in the test cup until all air bubbles have disappeared.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1097.

(*g*) Voltage shall be applied and increased uniformly at the rate of approximately 3 kv. (r.m.s. value) per second until electrical breakdown occurs as indicated by a continuous discharge across the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded.)

(*h*) After the breakdown and before removing the varnish from the test cup, the electrode surfaces shall be rubbed thoroughly with dry calendered tissue paper wrapped around a knife blade to provide stiffness. The test cup shall then be emptied and immediately refilled with the next filling of varnish to be tested.

(*i*) Five fillings shall be tested in conformity with the above procedure and the last filling of the cup shall drain the sample container.

Variations in Results.

32. Differences as great as 15 per cent may occur between different laboratories in the results of this test. This is considered satisfactory in view of the purpose of the test.

Report.

33. The report shall include the following:

(*a*) The kilovolts (r.m.s. value) at each electrical breakdown;

(*b*) The average value of the 5 breakdowns in kilovolts; and

(*c*) The mean deviation from the average value expressed as a percentage of the average breakdown value.

APPENDIX I

DESCRIPTION AND USE OF REMODELED MacMICHAEL VISCOSIMETER FOR DETERMINING VISCOSITY OF INSULATING VARNISHES

APPARATUS

The viscosity of varnishes may be determined by means of the remodeled MacMichael Viscosimeter shown in Figs. 1, 2 and 3. This instrument gives the viscosity values in terms of MacMichael degrees which are converted into absolute units of viscosity (centipoise) by means of the calibration curves of the various suspending wires.

In Fig. 1 the apparatus, consisting of the following parts, is shown unassembled:

A is the indicator by means of which the zero is adjusted and readings on scale *D* are taken.

B is the insulated wire suspension, the torsion of which measures the viscosity. The wire is fastened only at the bottom of its insulating sleeve *E'*. This is suspended by hanging it on points *P'*. (Ten wires of different size to cover various ranges of viscosities are supplied.)

C is the clamp screw which clamps the hollow spindle *E* to the sleeve *E'* which holds the torsion wire *B*.

D attached to hollow spindle *E* is the dial on which are calibrated the degrees MacMichael (300 deg. to the circumference). By means of this dial and indicator *A* the degrees deflection are determined as indicated in the method described below.

E is the hollow vertical spindle inside of which is the torsion wire sleeve *E'* which contains torsion wire *B*.

F is an oil-filled dash pot which acts as a brake to deaden oscillations and bring the suspension to rest quickly when making a determination. The dash pot swings between arm guides *F'* when the machine is assembled.

G is the brass disk which is attached to the bottom of vertical spindle *E*. Torsion wire *B* and *E'* is inserted into *E* and clamped with screw *C* and the disk *G* is then suspended in the liquid whose viscosity is being measured. Rotation of the sample cup *H* rotates the liquid and the rotating liquid exerts a certain force on the disk *G* partially rotating it and thus a torsion is produced in the wire suspension *B*, the deflection of which (or degree of torsion) is read from the scale on deflecting disk *D*.

H is the container which holds the sample. A locking device fastens it securely to *I* or *J*.

I is the water bath used for securing a uniform temperature in the liquid whose viscosity is being determined, when these viscosity measurements are desired at temperatures approximating that of the room (used on varnishes and oils).

J is the heating unit which is used in place of *I* when viscosity measurements are made at high temperatures (used on compounds).

K is the contact which carries the electric current to the heating unit cup *J*. It can be swung back when using cups *H* and *I* and when therefore electric heating is not desired.

L is the counter which indicates the revolutions per minute of the turntable *M*. A trip arrangement allows this counter to be lowered or raised, thus throwing the counter in or out of operation at will.

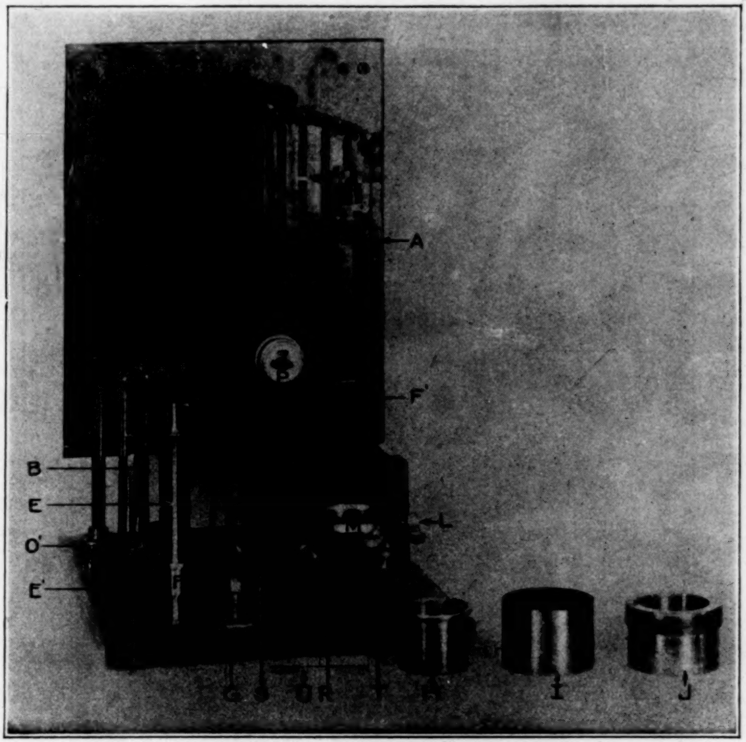


Fig. 1.—Improved MacMichael Viscosimeter Apparatus, Unassembled.

M is the rotating turntable in which *I* or *J* are set. A locking device (not shown) locks *I* or *J* securely to the turntable *M* so that when the turntable rotates the water bath or heating unit with the sample container also rotate.

N is the inclosing case under which is the motor and governor shown in Fig. 3. These operate turntable *M*.

O is a rheostat which controls the current going to the heating unit *J*.

O' is a rheostat controlling current for motor (shown only on remodeled instruments).

P is the knife switch (snap switch on new type machine) controlling the current for the heating unit *J*.

R is the push button which controls the electric current operating the motor shown in Fig. 3.

S is a leveling screw to level the instrument. Another such screw (not shown) is directly opposite to this one.

T is the governor screw that adjusts the speed of the motor by adjusting the governor shown in Fig. 3. In the remodeled apparatus the speed of rotation of turntable *M* can be decreased by moving the large gear in gear box away from the motor until pin of motor shaft is disengaged from slot of gear sleeve. The instrument is sent out with gear in low-speed position; to obtain high speeds shift gear toward motor until pin is engaged.

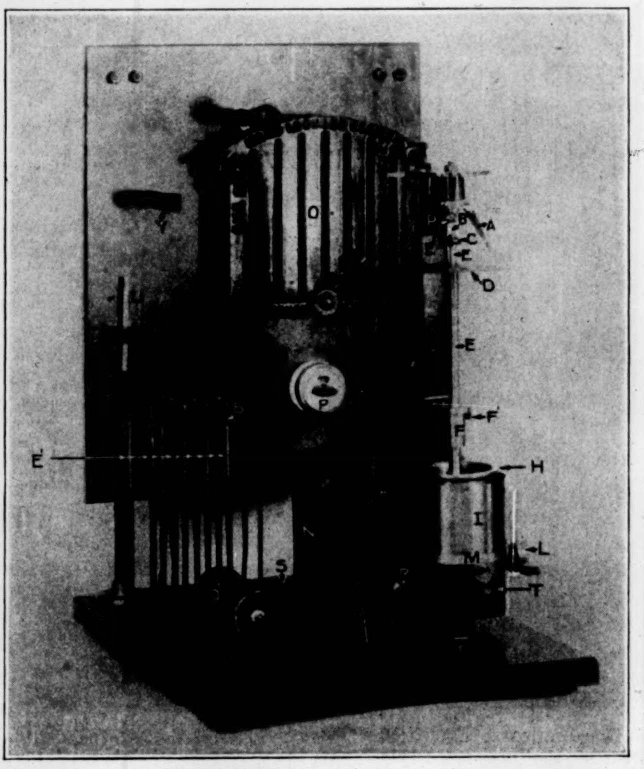


FIG. 2.—Improved MacMichael Viscosimeter Apparatus Assembled for Testing Varnish or Oil.

U is the measuring device used to measure the depth of the liquid in container *H*.

p are the projecting points on which the assembled spindle, namely, insulated torsion wire suspension *B* and *E'*, spindle and deflection dial *D*, and immersed disk *G* are suspended.

The apparatus is shown assembled in Fig. 2 for viscosity determinations on oil or varnish. Explanatory letters refer to the same parts as in Fig. 1.

In Fig. 3 are shown the internal structure and cup and heating unit assembled for testing compounds. The explanatory letters refer to the following:

V is the motor which operates the turntable *M*.

W is the governor controlling the speed of the turntable *M*.

X are the leads to connect instrument to 110-volt alternating current or direct current lighting circuit.

Y is the clamp holder for holding the spindle *E* with its dial *D*, when the machine is not in use (remodeled machines).

The heating unit *J* and the sample container, *H*, are here shown assembled as used in the viscosity determinations on compounds.

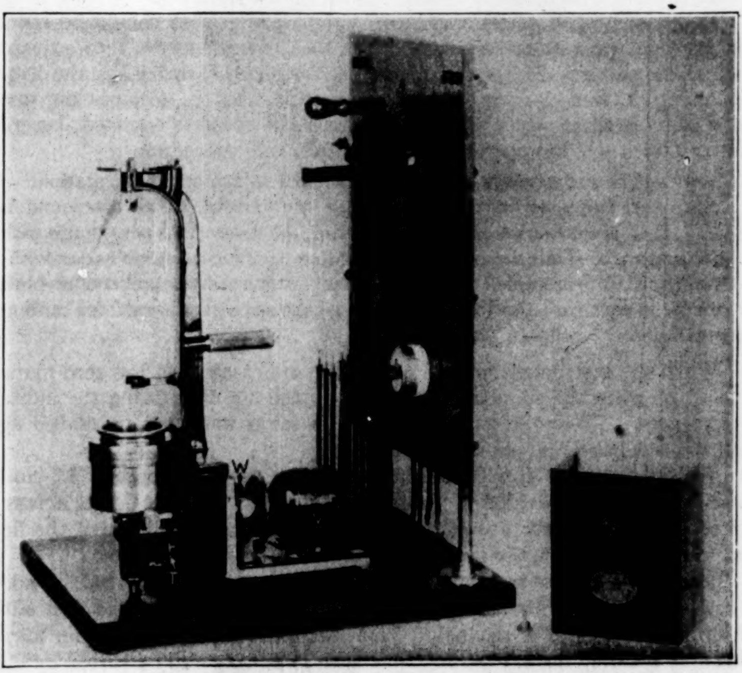


FIG. 3.—Improved MacMichael Viscosimeter Apparatus Showing Internal Structure and Cup and Heating Unit for Testing Compounds.

DIRECTIONS FOR MAKING VISCOSITY MEASUREMENTS ON VARNISH

Cups and disks must be perfectly clean. Otherwise reliable results cannot be obtained.

Dash pot *F* on the stem of the spindle should be two-thirds full of a medium grade of good machine oil (Etna Engine or Appollo) in order to dampen vibrations.

Use water bath *I* to secure and maintain the temperature of the sample in *H* when testing varnishes or oil.

Insert container *H* into water bath *I*. See that they are properly locked together, then lock bath *I* on turntable *M*.

Choose the proper torsion wire suspension for the liquid to be tested. Experience is the best guide to determine what suspension to use. Screw the disk *G* to the spindle *E*, and insert into *E* the proper insulated torsion wire suspension *F′*. Suspend these assembled parts from points *p* so the disk is suspended in the container *H*. Be sure to always suspend the wire on the points *p* with the flat side of the triangular button against the flat side of the supporting arm. The rounded surface of the triangle must face out towards the operator. Tightly fit the cover of the dash pot *F* on the arm guides F′.

See that the instrument is perfectly level. Use leveling screws *S* to adjust the instrument. The instrument is level when the suspended sleeve *E* swings exactly in the center of the hole of the cover on the dash pot.

Adjust the speed of the turntable to 60 r.p.m. This should be checked each time determinations are made. Use the governor screw *T* to adjust the speed of the motor. The gear in the gear box, referred to under *T* in the description of Fig. 1, should be in high speed position, that is, towards the motor. Use a stop watch to adjust the speed. After the speed is adjusted, lower the counter *L* so it will not operate during the following procedure.

NOTE.—The deflection is directly proportional to the speed of rotation. The 60 r.p.m. must therefore be maintained when the varnish, oil or compound is in the cup. It is, therefore, necessary to check first the revolutions per minute without the disk suspended in the sample, and again, when running a determination with the disk suspended in the sample. The motor must give the same number of revolutions per minute in each case and this value must be the same as was used for calibrating the suspension.

When the instrument is level adjust the indicator *A* to the zero mark on the dial *D*, when the spindle is suspended in the air, by moving the indicator as necessary. When the indicator has been set it must not be moved again until the test has been completed.

Fill the container *H* with the sample to be tested to a depth of 3.5 cm. A special device *U* is provided to measure this depth. Lay this device across the cup so the pointed end projects into the cup. When the surface of the liquid just touches the point, the depth of the liquid in the cup is 3.5 cm.

Raise or lower the temperature of the oil or varnishes to 21° C. by adding hot or cold water to the water bath, always stirring the sample well until a uniform temperature is secured. This is imperative. The sample may be stirred by rotating the sample cup frequently. It may also be stirred by lifting the spindle from the points *p* and stirring with the disk *G* holding the spindle by the barrel *E* and stirring by giving the disk an up-and-down movement in the sample cup. In the case of compounds, it is necessary to stir in this manner. In testing varnishes and oils, usually sufficient stirring can be obtained by rotating the cup while holding the barrel *E* to keep the disk stationary. If the spindle is removed from the points *p* it must always be suspended again with the same flat side of the supporting triangular button against the supporting arm so that the zero position is not changed.

If, when resuspending the spindle from points *p* it is noted that the zero point has moved, do not reset the indicator *A* as the change probably is due to some torsional effect produced by the sample. This may be especially noticed when testing compounds. Rotate the cup and take the reading without resetting the indicator.

When reading the thermometer have the bulb in the sample midway between the disk and the container wall and not resting on the bottom. Test the temperature at various points in the container to determine if a uniform temperature has been secured.

When a uniform temperature of 21° C. is secured, start the cup rotating by closing the switch *R*. Keep a hand on the switch and watch the scale on the disk *D*. If there is any danger that the deflection will go beyond the maximum limit for the suspension being used, open the switch immediately. Insert the next strongest wire suspension into the spindle and repeat as above indicated. When changing suspensions it is necessary to again set for zero. This may be accomplished without removing the sample, by simply removing the water bath, *I*, with its sample container, *H*, and then suspending the spindle with its new suspension on *p*, and leveling and adjusting as described above. It is necessary, of course, to thoroughly clean the disk, *G*, when doing this for if any varnish film should dry on the disk, the uneven or rough surface thus produced on the disk would cause an erroneous reading. A suspension wire should never be allowed to deflect beyond its maximum limit, for beyond this point a permanent set would be produced in the wire and a new calibration of the wire would have to be made or probably a new wire would have to be used. Table I gives a maximum and minimum limit for suspensions now in use. If the deflection is less than this minimum limit the next weakest suspension must be inserted and the test repeated. The reason for this is that at low deflections a change in slope appears on the calibration curve of the MacMichael degrees *versus* centipoises. The percentage error is magnified here and hence a reading that comes up higher in the calibration curve should be used. The maximum limit given may not be the limit to which it is permissible to deflect the wire in order to prevent its acquiring a permanent set. It, however, happens to be the limit of the calibration curve available for that suspension when the wire was calibrated

TABLE I—MAXIMUM AND MINIMUM LIMITS FOR SUSPENSIONS.

Suspension Number (B. & S. Gage No.)	Minimum Deflection, deg. MacMichael	Approximate Equivalent Centipoise Reading	Maximum Deflection, deg. MacMichael	Approximate Equivalent Centipoise Reading
30 (Weakest)	30	18	125	89
28	20	35	100	200
26	7.5	30	35	175
24	5	70	32.5	400
22	10	200	45	975
21	5	225	40	1800
20	10	750	50	4200
18	4	700	24	4000
16	2	750	11	4000
14 (Strongest)	1	1375	5	5500

Record the deflection in degrees MacMichael and read the viscosity in centipoises from the calibration curve of the suspension used.

NOTE 1.—Before any sets of suspensions are used, they must be calibrated as noted under heading "Calibration of Suspensions."

NOTE 2.—The following table gives the diameter of the wires (new American music wire gage) used in making the suspensions and the maximum limit of torsion in degrees MacMichael to which they may be subjected before they acquire a permanent set:

SUSPENSION NUMBER (B. & S. Gage No.)	DIAMETER WIRE, IN.	TORSIONAL LIMIT, DEG. MACMICHAEL
30 (Weakest)	0.0100	125
28	0.0126	118
26	0.0159	110
24	0.0201	102
22	0.0254	92
21	0.0285	81
20	0.0320	73
18	0.0403	55
16	0.0508	35
14 (Strongest)	0.0641	5

NOTE 3.—Not all of the suspension noted above are required in testing varnish. Suspensions 22, 21 and 20 will be sufficient for practically all varnishes. The heavier wires 18, 16 and 14 are used for very viscous materials.

CALIBRATION OF SUSPENSIONS.

In order to calibrate the torsion wire suspensions used in this apparatus to measure viscosity, a number of samples of oil and a sample of pure castor oil should be prepared and sent to the U. S. Bureau of Standards for determination of absolute viscosity at various temperatures. The following are typical data as supplied by the Bureau of Standards on four standard samples of oil:

OIL SAMPLE	TEMPERATURE, DEG. CENT.	VISCOSITY, CENTIPOISES
No. 1. Mineral Oil (Transformer) 63 seconds Saybolt viscosity at 100° F.	10 20 30	29.95 18.6 12.44
No. 2. Mineral Oil (Transformer) 104 seconds Saybolt viscosity at 100° F.	10 20 30	72.50 41.02 25.40
No. 3. Mineral Oil (Lubricating) 297 seconds Saybolt viscosity at 100° F.	10 20 30	405 169.9 89.64
No. 4. Castor Oil, U. S. P. (AA)	10 15 20 25	2693 1704 1104 746

The viscosity of sample No. 1 is so low that even with the weakest suspension only a very small deflection is secured. As the percentage of error is higher at small deflections than at large deflections, such a sample should not be used. These samples must have their absolute viscosities checked at least once a year as it has been found that the oils undergo some change on standing over long periods.

The calibration of the wires is made by testing the standardized samples of oil, following the directions as given above under heading "Directions for Making Viscosity Measurement on Varnishes." Tests are made at the same temperatures as used by the Bureau of Standards for their absolute viscosity tests. The above standard samples would be used as follows:

	Suspension Number
Sample No. 2 at 10° C.—20° C.—30° C.	30, 28, 26, 24, 22 and 21
" " 3 " 10° C.—20° C.—30° C.	21
" " 3 " 20° C.—30° C.	26, 24, 22 and 21
" " 4 " 10° C.	18, 16 and 14
" " 4 " 15° C.	20, 18, 16 and 14
" " 4 " 20° C.	21, 20, 18 and 16
" " 4 " 25° C.	21, 20, 18 and 16

The degrees MacMichael obtained for each suspension on each sample at each temperature are plotted against corresponding U. S. Bureau of Standards absolute viscosity figures (centipose) for those samples at the same temperatures and a line is drawn through these points. The line should be straight except possibly at low deflections where the error is correspondingly high.

Once every two months the suspensions should be recalibrated. In this recalibration the viscosities obtained as read from the plotted curve are compared with the Bureau of Standards viscosities and if they agree within 10 per cent, the curve need not be replotted. In cases of low viscosities 15 per cent error is allowable. If the majority check tests show a larger error, a new curve should be plotted for the suspension.

APPENDIX II

DIELECTRIC STRENGTH TESTS ON COPPER BASE

Where it is desired to make dielectric strength tests of solid films of varnish (as distinguished from the specimens prescribed in the methods, which are a combination of varnish and paper fibers), it is recommended that copper be used as the base as formerly required in the methods. The following are the directions for preparing and testing such specimens:

1. (*a*) Specimens are prepared by dipping pieces of thoroughly cleaned, smooth sheet copper or brass about 20 cm. (7.88 in.) square and about 0.127 mm. (0.005 in.) thick into the varnish which is at the consistency prescribed in Section 5 (*b*) of the methods.

(*b*) Each specimen is dipped twice, once in each direction, in order to give a more uniform thickness of coating. The specimen is dried after each dip in the same vertical position in which it was dipped.

(*c*) Specimens of air-drying varnish are dried in free air after each dip at a room temperature of approximately 20° C. (68° F.) for a period six times as long as that determined in accordance with Section 7 of the methods.

(*d*) Specimens of baking varnish are drained and then baked after each dip for a period three times as long as that determined in accordance with Section 7 of the methods.

(*e*) The final thickness of the film of varnish on each side of the specimen is between 0.044 mm. (0.0018 in.) and 0.052 mm. (0.002 in.).

2. (*a*) The dielectric strength of the two films of varnish is determined by applying alternating potential to two circular metal disks, 5.08 cm. (2.0 in.) in diameter and with edges rounded to a radius of 0.64 cm. (0.25 in.) which are placed in contact with the two sides of the specimen directly opposite each other and under a pressure of approximately 0.5 kg. (1.1 lb.). Starting at zero, the voltage shall be increased at a rate of approximately 0.5 kv. per second. The electrodes shall be polished and cleaned after each puncture. As the temperature of the electrodes increases after a number of tests, it is advisable to change the electrodes after every twenty punctures. Ten such punctures are to be made at various points selected at random on each specimen. After testing, the thickness of the specimen shall be determined by making five measurements on a strip cut diagonally across the specimen. The measurements shall be equally spaced along the strip except in the case of a measurement being to close to a point of puncture. The average of the five measurements shall be considered as the thickness of the specimen.

NOTE.—When necessary, in order to get ten punctures, additional specimens should be tested.

(*b*) The frequency of the test potential shall be not greater than 100 cycles per second, and each part of the testing apparatus shall have a continuous rating of not less than 2 kva. (preferably larger). The wave form shall be a sine curve as defined, and the voltage shall be measured by methods approved by the American Institute of Electrical Engineers.

(*c*) The voltage may be controlled by any approved method which does not distort the wave form beyond the limits prescribed above and which does not subdivide the voltage in steps greater than 100 volts. The apparatus shall comply with the Standards of the American Institute of Electrical Engineers.

3. The volts at puncture, the net thickness of insulation and the volts per mil of net thickness shall be reported for each of the ten tests together with the average, maximum and minimum volts per mil.

TENTATIVE SPECIFICATIONS
FOR
INSULATED WIRE AND CABLE: CLASS AO, 30 PER CENT HEVEA RUBBER COMPOUND[1]

A.S.T.M. Designation: D 27 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1916; REVISED, 1921, 1928, 1931, 1933, 1934.[2]

Scope

1. These specifications cover the conductors, insulation, cable tape, cotton braid and lead sheaths of Class AO rubber insulated wire and cable. The design and factor of safety depend upon the service conditions and shall be at the option of the purchaser.

(*A*) CONDUCTOR

MANUFACTURE

Material

2. The conductor shall be of soft annealed copper, properly tinned, and have the properties and characteristics herein required.

Strand

3. Each individual wire of a stranded conductor shall be considered separately and shall be designated as a strand.

Shape

4. Each solid conductor and each strand shall be round and reasonably free from imperfections.

Stranding

5. The stranding shall conform to the requirements of Table I and shall be either standard concentric or flexible as specified in the order.

Density

6. For the purpose of calculating weights, cross-sections, etc., in conductivity determinations, the density of copper shall be taken as 8.89 g. per cu. cm. (See Appendix.)

PERMISSIBLE VARIATIONS IN DIMENSIONS

Diameter and Area

7. (*a*) *Permissible Variation.*—When the diameter of solid conductors and strands is specified, the permissible variation from the

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

specified value shall not exceed 1 per cent under or 2 per cent over for wire 0.02 in. in diameter and larger, and 0.1 mil under for wire less than 0.02 in. in diameter.

NOTE.—These limits differ from those in the Standard Specifications for Tinned Soft or Annealed Copper Wire for Rubber Insulation (A.S.T.M. Designation: B 33) of the American Society for Testing Materials[1] because of the additional manipulation to which the wire is subjected subsequent to the stage where Specifications B 33 apply.

When the area of cross-section of cables is specified, the permissible variation shall not exceed 1 per cent under the specified value.

(*b*) *Method of Gaging Diameter*.—When wire is submitted in coils, each coil shall be gaged in three places, one near each end and one approximately at the middle. When wire is submitted on spools or reels, approximately 12 ft. of the wire shall be reeled off and the wire then gaged in six places between the second foot and the twelfth foot from the end.

TABLE I.—STRANDING OF INSULATED CONDUCTORS.

For intermediate sizes use stranding for next larger size.

Conductors of No. 0000 and smaller are often made solid and this table of stranding should not be interpreted as excluding such practice.

In assembly column, "37 by 19 rope lay," signifies 37 strands of 19 wires assembled like a rope.

Size of Conductors	Standard Concentric Stranding,[a] Number of Wires	Flexible Stranding	
		Number of Wires	Assembly
2 000 000 cir. mils	127	703	37 by 19 rope lay
1 500 000 cir. mils	91	703	37 by 19 rope lay
1 000 000 cir. mils	61	427	61 by 7 rope lay
500 000 cir. mils	37	427	61 by 7 rope lay
300 000 cir. mils	37	259	37 by 7 rope lay
0 000 A. w. g	19	133	19 by 7 rope lay
1 A. w. g	19	91	Concentric
2 A. w. g	7	91	Concentric
4 A. w. g	7	61	Concentric
10 A. w. g	7	37	Concentric
16 A. w. g	7	26	Bunched
18 A. w. g	7	16	Bunched
20 A. w. g	7	10	Bunched

[a] The standard concentric stranding in this table agrees with Table XII of *Circular No. 31*, "Copper Wire and Cables," U. S. Bureau of Standards; and also Table II of Standard No. 30 "Wires and Cables" of the American Institute of Electrical Engineers.

(*c*) *Calculation of Area*.—The area of cross-section of wire shall be calculated from the average of the measurements of the diameter made in accordance with Paragraph (*b*). The area of cross-section of cable shall be considered to be the sum of the cross-sectional areas of its component wires, when laid out straight and measured perpendicular to their axes.

(*d*) *Rejection*.—A coil or reel shall be rejected if the average diameter obtained from the measurements made in accordance with Paragraph (*b*), or the area calculated in accordance with Paragraph (*c*), is not within the limits specified in Paragraph (*a*).

A coil or reel shall be rejected if any individual measurement of diameter or of area of cross-section is not within twice the limits of Paragraph (*a*).

---

[1] 1933 Book of **A.S.T.M. Standards, Part** I, p. 777.

PHYSICAL PROPERTIES AND TESTS

Tensile Properties

8. (*a*) Each solid conductor and each strand previous to stranding shall be so drawn and annealed that after tinning it shall conform to the values in Table II.

After stranding, the tensile strength of each strand shall not exceed that specified in Table II by more than 5 per cent and the minimum elongation in 10 in. shall not be less than that specified in Table II by more than 5 per cent.

(*b*) For nominal diameters between listed sizes the requirements shall be those of the next larger sizes indicated in Table II.

Tension Tests

9. (*a*) *Method of Test.*—Tension tests shall be made on fair samples and the elongation shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks originally 10 in. apart. The specimen shall break between the bench marks and not closer than 1 in. to either mark.

TABLE II.—TENSILE REQUIREMENTS OF CONDUCTORS.

Size of Conductor		Maximum Tensile Strength, lb. per sq. in.	Minimum Elongation in 10 in., per cent
Diameter, in.	A.w.g. Number		
0.460 to 0.290	0000 to 1	36 000	30
0.289 to 0.103	2 to 10	37 000	25
0.102 to 0.021	12 to 24	38 500	20
0.020 to 0.012	25 to 28	39 000	15
0.011 to 0.003	29 to 40	40 000	10

(*b*) *Number of Tests.*—Samples shall be taken in accordance with Section 26.

(*c*) *Retests and Rejections.*—If upon testing a sample from a coil, reel or spool of wire, the results are found to be above the stated value for tensile strength or below the stated value for elongation, tests upon two additional samples will be made and the average of the three tests shall determine acceptance or rejection.

Conductivity

10. The conductivity of the conductors after tinning shall be not less than that specified in Table III.

TABLE III.—CONDUCTIVITY REQUIREMENTS.

DIAMETER, IN.	A.W.G. NUMBER	CONDUCTIVITY, PER CENT
0.460 to 0.290	0000 to 1	97.65
0.289 to 0.103	2 to 10	97.15
0.102 to 0.021	12 to 24	96.15
0.020 to 0.012	25 to 28	94.15
0.011 to 0.003	29 to 40	93.15

NOTE.—The above values for conductivity conform to the International Annealed Copper Standard. (See Appendix I.)

Tinning Test

11. (*a*) The continuity of the tin coating of each sample before stranding or insulating shall be determined by the sodium polysulfide test which shall be made in accordance with the requirements of Sections 4 to 10, inclusive, of the Standard Specifications for Tinned Soft or Annealed Copper Wire for Rubber Insulation (A.S.T.M. Designation: B 33) of the American Society for Testing Materials.[1]

(*b*) *Number of Tests.*—Samples shall be taken in accordance with Section 25.

(*c*) *Retests and Rejections.*—If the specimens tested in accordance with Paragraph (*a*) shows any signs of blackening, two more specimens shall be tested. If one of these two additional specimens shows any blackening, that coil or reel shall be rejected. If both specimens are free from any signs of blackening, the coil or reel shall be accepted. If more than 10 per cent of the samples in the entire order fail, all of the wire shall be rejected. If 10 per cent or less of the samples in the entire lot fail, each coil, reel or length may be tested and accepted or rejected upon the results of the individual tests.

(*B*) INSULATION

Workmanship

12. (*a*) Wires and cables ordered under these specifications shall be insulated with Class AO rubber compound. Where Class A rubber compound is desired, the order shall be placed under the Tentative Specifications for Insulated Wire and Cable: Class A, 30 per cent Hevea Rubber Compound (A.S.T.M. Designation: D 393 – 34 T),[2] and where performance rubber compound is desired, under the Tentative Specifications for Insulated Wire and Cable: Performance Rubber Compound (A.S.T.M. Designation: D 353 – 34 T)[3] of the American Society for Testing Materials.

(*b*) The insulation shall consist of a properly vulcanized rubber compound which shall be homogeneous in character, tough, elastic and applied concentrically about the conductor and shall fit tightly thereto. Where the insulation is applied in more than one layer, adjacent layers shall be vulcanized into a homogeneous mass.

(*c*) *Shielding.*—Braided cables on ungrounded neutral circuits of 3501 v. and over and braided cables on grounded neutral circuits of 6001 v. and over, which are not to be supported on insulators, shall have shielding over the insulation.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 777.

[2] See p. 1126.

[3] See p. 1128.

The individual conductors of lead-covered, multiple conductor cables, operating at from 6000 to 8000 v., inclusive, with the neutral ungrounded, shall be suitably shielded.

The shielding shall consist of a thin tinned copper tape or a braid of fine tinned copper wires.

(*d*) The insulation of braided wires up to No. 7 A.w.g., inclusive, shall be covered with a single cotton braid. On larger sizes the fibrous covering shall consist of a cable tape and a cotton braid or two cotton braids. The cable tape shall conform to the requirements specified in Sections 50 to 53, inclusive. The cotton braid shall be applied in accordance with Sections 54 to 58, inclusive, and shall be finished in accordance with Sections 59 and 60.

(*e*) Where repairs or joints are made in the insulation, the work shall be done in such manner that the repaired part of the joint, and all parts affected in the process, shall be as strong and durable electrically and mechanically as the remainder of the insulation and shall not exceed the limitations on the thickness specified in Section 17.

MANUFACTURE

Composition

13. (*a*) Class AO rubber compound shall contain exclusively not less than 30 per cent nor more than 33 per cent of the best quality Hevea rubber which has not previously been used in a rubber compound, solid waxy hydrocarbons, suitable mineral matter, antioxidants, organic accelerators, and sufficient sulfur to properly vulcanize the compound.

(*b*) The mineral matter shall be dry.

(*c*) The waxy hydrocarbons used shall be solid at 54° C. and shall be free from saponifiable matter.

(*d*) Contamination of the compound, such as by the use of impregnated tapes, will not excuse the manufacturer from conforming to these specifications.

CHEMICAL PROPERTIES

Quantitative Requirements

14. The insulation after vulcanization shall conform on analysis to the following requirements expressed as percentages by weight of the whole sample:

	MAXIMUM	MINIMUM
Rubber, per cent	33	30
Waxy hydrocarbons, per cent	4	..
Free sulfur, per cent	0.7	..

	30 PER CENT RUBBER[a]	33 PER CENT RUBBER[a]
Saponifiable acetone extract, max., per cent	2.00	2.20
Unsaponifiable resins, max., per cent	1.00	1.10
Chloroform extract, max., per cent	0.90	1.00
Alcoholic potash extract, max., per cent	0.55	0.60
Total sulfur, max., per cent	2.10	2.30

---

[a] For percentages between 30 and 33, the limits shall be in proportion to the percentage of rubber found.

Qualitative Requirements

15. (*a*) The acetone solution shall not fluoresce.

(*b*) The hydrocarbons shall be solid, waxy and not darker than a light brown.

(*c*) The chloroform extract (60 ml.) shall not be darker than a straw color.

PHYSICAL PROPERTIES

Physical Properties

16. The insulation shall conform to the following requirements as to physical properties:

Tensile strength, min., lb. per sq. in		1200
Tensile stress at 200 per cent elongation, min., lb. per sq. in		300
Elongation at rupture, min., per cent		400
Set in 2-in. gage length, max., in		$\frac{3}{8}$
Depreciation in tensile strength and elongation after oxygen bomb test, max., per cent		25
Depreciation in tensile strength and elongation after Geer oven test, max., per cent		15
Specific gravity, min	30 per cent rubber	1.75[a]
	33 per cent rubber	1.67[a]

---

[a] For percentages between 30 and 33, the specific gravity limits shall be in proportion to the percentage of rubber found.

THICKNESS

Thickness

17. (*a*) The average thickness of the insulation shall be not less than that given in Table IV. The minimum thickness shall be within 95 per cent of the prescribed thickness for insulations less than $\frac{4}{64}$ in. and within 90 per cent of the specified thickness for insulations from $\frac{4}{64}$ in. to $\frac{18}{64}$ in., inclusive.

(*b*) The thicknesses in Table IV apply to single conductor cable and the individual conductors of multiple conductor cables, leaded or braided, except special applications such as aerial, non-leaded submarine, and vertical riser cable.

NOTE.—In Appendix II will be found an interpretation of the insulation thicknesses given in Table IV.

TABLE IV.—THICKNESS OF INSULATION AND ALTERNATING TEST VOLTAGE (SEE NOTE 3).

NOTE 1.—Rated circuit voltage of alternating-current circuits is the phase-to-phase voltage.

NOTE 2.—For an intermediate size of wire or an intermediate rated circuit voltage the thickness and test voltage shall be that for the next larger size or higher rated circuit voltage.

NOTE 3.—For d. c. systems over 2000 volts consult the manufacturer. Above 5000 volts, a. c. special high-voltage rubber compounds are preferred according to the manufacturer's recommendations.

NOTE 4.—In voltage groups from 6001 to 7000 volts, and 7001 to 8000 volts, size No. 8 wire with the same insulation as No. 7 wire is allowable for series street lighting service.

Rated Circuit Voltage	Size of Conductor, A. w. g. Numbers or Circular Mils	Insulation Thickness on each Conductor, sixty-fourths of an inch		Test Voltage, kv.	
		Grounded	Ungrounded	Grounded	Ungrounded
0 to 600	No. 14 to No. 9	3	3	3	3
	No. 8 to No. 2	4	4	3.5	3.5
	No. 1 to No. 0000	5	5	4	4
	225 000 to 500 000 cir. mils	6	6	5	5
	525 000 to 1 000 000 cir. mils	7	7	6	6
	Over 1 000 000 cir. mils	8	8	7	7
601 to 1000	No. 14 to No. 8	4	4	4	4
	No. 7 to No. 2	5	5	5	5
	No. 1 to No. 0000	6	6	6	6
	225 000 to 500 000 cir. mils	7	7	7	7
	525 000 to 1 000 000 cir. mils	8	8	8	8
	Over 1 000 000 cir. mils	9	9	9	9
1001 to 2000	No. 14 to No. 8	5	5	5	5
	No. 7 to No. 2	6	6	6	6
	No. 1 to No. 0000	7	7	7	7
	225 000 to 500 000 cir. mils	8	8	8	8
	525 000 to 1 000 000 cir. mils	9	9	9	9
	Over 1 000 000 cir. mils	9	9	9	9
2001 to 3000	No. 14 to No. 8	7	7	7	7
	No. 7 to No. 2	8	8	8	8
	No. 1 to No. 0000	8	8	8	8
	225 000 to 500 000 cir. mils	9	9	9	9
	525 000 to 1 000 000 cir. mils	9	9	9	9
	Over 1 000 000 cir. mils	10	10	10	10
3001 to 4000	No. 14 to No. 8	9	9	9	9
	No. 7 to No. 2	9	9	9	9
	No. 1 to No. 0000	9	9	9	9
	225 000 to 500 000 cir. mils	10	10	10	10
	525 000 to 1 000 000 cir. mils	10	10	10	10
	Over 1 000 000 cir. mils	11	11	11.5	11.5
4001 to 5000	No. 14 to No. 8	10	10	10	10
	No. 7 to No. 2	10	10	10	10
	No. 1 to No. 0000	10	10	10	10
	225 000 to 500 000 cir. mils	11	11	11.5	11.5
	525 000 to 1 000 000 cir. mils	11	11	11.5	11.5
	Over 1 000 000 cir. mils	12	12	13	13
5001 to 6000	No. 14 to No. 8	10	12	10	13
	No. 7 to No. 2	10	12	10	13
	No. 1 to No. 0000	10	12	10	13
	225 000 to 500 000 cir. mils	11	12	11.5	13
	525 000 to 1 000 000 cir. mils	11	12	11.5	13
	Over 1 000 000 cir. mils	12	13	13	14.5
6001 to 7000	No. 7 to No. 2	11	14	11.5	16
	No. 1 to No. 0000	11	14	11.5	16
	225 000 to 500 000 cir. mils	11	14	11.5	16
	525 000 to 1 000 000 cir. mils	11	14	11.5	16
	Over 1 000 000 cir. mils	12	15	13	17.5
7001 to 8000	No. 7 to No. 2	12	16	13	19
	No. 1 to No. 0000	12	16	13	19
	225 000 to 500 000 cir. mils	12	16	13	19
	525 000 to 1 000 000 cir. mils	12	16	13	19
	Over 1 000 000 cir. mils	13	17	14.5	20.5

ELECTRICAL PROPERTIES

High Voltage Test

18. Each coil, reel, or length of wire or cable, after vulcanization and before the application of any covering other than tape or braid used in vulcanization shall successfully withstand the application of an alternating voltage of not less than that given in Table IV for a period of 5 minutes.

Insulation Resistance

19. Each coil, reel, or length of wire or cable after being subjected to the high voltage test specified in Section 18 shall have an insulation resistance not less than that given in Table V.

Moisture Absorption

20. (*a*) The increase in the specific inductive capacity of the insulation shall be used as an indication of the amount of moisture asborbed.

(*b*) The specific inductive capacity after 24-hr. immersion in water shall not exceed six. The increase between the ends of the first and the fourteenth days shall not exceed 20 per cent and that between the ends of the seventh and fourteenth days, 5 per cent.

(*c*) The specific inductive capacity shall be determined at either 1000 or 60 cycles. Where measured at 1000 cycles, the voltage impressed upon the conductor shall not exceed 10 volts. Where measured at 60 cycles, the voltage impressed upon the conductor shall be equivalent to a stress of between 30 to 40 volts per mil of insulation.

(*d*) The measurements shall be made as described in Section 49.

METHODS OF TESTING

CHEMICAL ANALYSIS

Sampling

21. Samples of the vulcanized rubber compound for chemical analysis shall be taken after the successful completion of the physical and electrical tests, and before applying impregnating compounds which may contaminate the rubber. The samples shall be taken at the option of the purchaser. The purchaser shall assure himself that all samples are free from contamination and change due to torch heating. Wherever practicable, samples shall be taken at a distance of at least 3 ft. from the end of the wire.

Procedure

22. The insulation shall be analyzed in accordance with **(*B*) Complete Procedure** as described in the **Standard Methods of**

Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297) of the American Society for Testing Materials.[1]

TABLE V.—INSULATION RESISTANCE, MEGOHMS-1000 FT. AT 60° F. (15.5° C.).

NOTE 1.—This table is based on a constant, $K = 21\,120$ in the following formula:

$$R = K \log_{10} \frac{D}{d};\ \text{where } R = \text{resistance in megohms-1000 ft.}, K = \text{constant}.$$

D = diameter over insulation, on each conductor, and d = diameter over conductor.

NOTE 2.—For an intermediate size, the insulation resistance shall be that of the next larger size.

Size of Conductor, A. w. g. Numbers or Circular Mils	Thickness of Insulation in Sixty-fourths of an Inch							
	2	3	4	5	6	7	8	10
No. 18	8400	10 800	....	....	....	....	....	....
No. 16	7400	9 500	....	....	....	....	....	....
No. 14	....	8 100	9 800	11 400	12 400	13 500	14 000	16 100
No. 12	....	7 100	8 400	9 800	10 800	11 900	12 700	14 500
No. 10	....	6 050	7 150	8 400	9 500	10 600	11 400	12 700
No. 8	....	4 500	5 550	6 600	7 650	8 700	9 200	10 800
No. 6	....	....	4 500	5 550	6 350	7 150	7 650	9 200
No. 4	....	....	3 950	4 500	5 300	6 050	6 600	7 650
No. 2	....	....	3 450	3 950	4 500	5 000	5 550	6 600
No. 1	....	....	3 150	3 450	3 950	4 500	5 300	6 050
No. 0	....	....	....	3 150	3 700	4 200	5 000	5 550
No 00	....	....	....	2 900	3 450	3 950	4 500	5 000
No. 000	....	....	....	2 650	3 150	3 450	3 950	4 500
No. 0000	....	....	....	2 400	2 900	3 150	3 450	4 200
250 000 cir. mils	....	....	....	2 100	2 500	3 050	3 300	3 850
350 000 cir. mils	....	....	....	1 850	2 250	2 500	2 750	3 550
500 000 cir. mils	....	....	....	1 600	2 000	2 100	2 500	3 050
750 000 cir. mils	....	....	....	....	....	1 700	2 100	2 500
1 000 000 cir. mils	....	....	....	....	....	1 600	1 700	2 100
1 250 000 cir. mils	....	....	....	....	....	....	1 700	2 000
1 500 000 cir. mils	....	....	....	....	....	....	1 600	1 700
1 750 000 cir. mils	....	....	....	....	....	....	1 450	1 600
2 000 000 cir. mils	....	....	....	....	....	....	1 050	1 450

Size of Conductor, A. w. g. Numbers or Circular Mils	Thickness of Insulation in Sixty-fourths of an Inch			
	12	14	16	18
No. 14	17 700	....	....	....
No. 12	15 800	....	....	....
No. 10	14 000	....	....	....
No. 8	11 600	12 700	13 700	14 500
No. 6	10 300	11 100	12 100	12 900
No. 4	8 700	9 800	10 600	11 400
No. 2	7 650	8 400	9 000	9 800
No. 1	7 150	7 650	8 400	9 200
No. 0	6 350	7 150	7 900	8 400
No. 00	5 550	6 600	7 150	7 900
No. 000	5 300	6 050	6 600	7 150
No. 0000	5 000	5 550	6 050	6 600
250 000 cir. mils	4 600	5 300	5 800	6 350
350 000 cir. mils	4 100	4 500	5 000	5 550
500 000 cir. mils	3 550	3 950	4 500	4 750
750 000 cir. mils	2 750	3 300	3 700	4 100
1 000 000 cir. mils	2 500	2 900	3 300	....
1 250 000 cir. mils	2 250	2 650	3 050	....
1 500 000 cir. mils	2 100	2 500	....	....
1 750 000 cir. mils	2 000	2 400	....	....
2 000 000 cir. mils	1 700	2 250	....	....

Rejection and Retests

23. The purchaser may make a chemical analysis on any one of the samples selected as described in Section 21 to determine if the

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1130.

compound conforms to the requirements of Sections 14 and 15. Failure of any sample selected to conform to the requirements shall be sufficient cause for rejecting the wire which that sample represents, except in the case of failure to conform to the requirements for either or both free sulfur and chloroform extract. In case of such failure, the coil from which the sample was taken shall be rejected and two additional samples shall be selected from the remainder of the order. The remainder of the order shall be accepted if both samples so selected conform to the requirements for free sulfur or chloroform extract. The entire order shall be rejected if either sample fails.

SPECIFIC GRAVITY

Specific Gravity

24. The specific gravity shall be determined in accordance with Section 27 of the Standard Methods of Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297) of the American Society for Testing Materials.[1]

TENSILE STRENGTH, SET AND ELONGATION AT RUPTURE

Sampling for Tests

25. (*a*) Wire up to and including 250,000 cir. mils in size shall be sampled in accordance with the following requirements:

	NUMBER OF SAMPLES
2000 ft. and under	none
2001 to 10,000 ft.	1 for each 2000 ft. or fraction thereof
10,001 to 100,000 ft.	5 plus 1 for each 10,000 ft. additional over 10,000 ft.
100,001 to 500,000 ft.	14 plus 1 for each 25,000 ft. over 100,000 ft.

(*b*) For wire larger than 250,000 cir. mils, one sample shall be selected from quantities between 1000 and 2000 ft. and for larger quantities double those specified in Paragraph (*a*).

Test Specimen

26. (*a*) *Size.*—The test specimen may be the entire section of the insulation in the case of small wires, or, in the case of a large wire or cable, either a segment of a section cut with a sharp knife held tangentially to the conductor or a shaped specimen cut out with a standard die. The test specimen shall be as free as possible from surface incisions and imperfections. There shall be no limit to the cross-section of the test specimen, except as restricted by the capacity of the testing machine.

NOTE.—The removal of the rubber insulation can be greatly accelerated and in most cases a test specimen which is an entire section can be obtained free from surface incisions and imperfections by means of metallic mercury. The mercury should be introduced at one end of the sample between the insulation and the tinned surface of the conductor, and the sample inclined on a support with the end to which the mercury is applied at the top. The separation of the rubber insulation results from the amalgamation of the tin of the conductor with the mercury. The amalgamation is assisted by first immersing and rubbing the tinning on the exposed end of the conductor in the mercury.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1130.

(*b*) *Condition and Age.*—Specimens shall not be heated, immersed in water or subjected to any mechanical or chemical treatment not specifically prescribed in these specifications. Specimens for accelerated aging tests shall be taken from the completed wire after the application of the specified covering and shall be aged with all such covering removed. No tests shall be made within 24 hours nor later than 60 days after vulcanization unless agreed to by the manufacturer.

(*c*) *Buffing.*—In the event of any irregularities on the surface of the test specimen, it shall be made smooth and of uniform thickness within 5 per cent of the original thickness by buffing, except when large strands are used, in which case the rubber sample shall be buffed sufficiently to remove all corrugations.

Calculation of Area

27. Calculation of the area of the test specimens shall be made as follows:

(*a*) Where the total cross-section of the insulation is used, the area shall be taken as the difference between the area of the circle whose diameter is the minimum average outside diameter of the insulation and the area of the conductor. The area of a stranded conductor shall be calculated from its maximum diameter.

(*b*) Where a slice cut from the insulation by a knife held tangent to the wire is used, and the slice so cut has the cross-section of a segment of a circle, the area shall be calculated as that of the segment of a circle whose diameter is that of the insulation. The height of the segment is the wall of insulation on the side from which the slice is taken. (The values may be obtained from a table giving the areas of segments of a unit circle for the ratio of the height of the segment to the diameter of the circle.)

(*c*) Where the cross-section of the slice is not a segment of a circle, the area shall be calculated from a direct measurement of the volume or from the specific gravity and the weight of a known length of the specimen having a uniform cross-section.

(*d*) Where a portion of a sector of a circle has to be taken where the conductor is large and the insulation thin, the area shall be calculated as the thickness times the width. (This applies either to a straight test piece or one stamped out with a die, and assumes that corrugations have been removed by buffing.)

(*e*) Where a portion of a sector of a circle has to be taken where the conductor is large and the insulation thick, the area shall be calculated as the proportional part of the area of the total cross-section.

Temperature at Test

28. Physical tests shall be made at a room temperature not less than 65° F. (18.3° C.) nor more than 90° F. (32.2° C.) and the test specimen shall have been kept at the room temperature not less than 30 minutes prior to the test.

Tension Testing Machine

29. The tension testing machine shall be power-driven and preferably of the pendulum type. The machine shall be accurate within 1 per cent of the breaking load. A spring balance type of apparatus may be used if provided with a device which will indicate the actual maximum load at which rupture takes place and if provision is made to prevent recoil of the spring.

Tensile Strength Test Procedure

30. The tensile strength test shall be made on a specimen which has not been previously stretched. The specimen shall have a length of not less than 6 in., and shall be marked with gage marks 2 in. apart and placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. The specimen shall be stretched at the rate of 20 in. per minute (jaw speed) until it breaks. The test specimen shall break between the gage marks. The tensile strength shall be calculated upon the area of the original specimen.

Tensile Stress Test

31. The tensile stress test shall be made in conjunction with the tensile strength test by recording the load when the 2-in. gage length marks are 6 in. apart, that is, at 200 per cent elongation. The tensile stress shall be calculated upon the original area of the specimen.

Elongation at Rupture Test Procedure

32. The percentage of elongation at rupture shall be determined simultaneously with the tensile strength and on the same specimen.

The elongation at rupture shall be taken as the distance between gage marks at rupture less 2 in. (the original gage length of the set test specimen). The percentage of elongation at rupture is the elongation in inches divided by the original gage length (2 in.) and multiplied by 100 to express as a percentage.

Set Test Procedure

33. The set test shall be made on a separate test specimen having a length of not less than 6 in. and marked with gage marks 2 in. apart.

The specimen shall be placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. and shall be stretched at the rate of 20 in. per minute (jaw speed) until the gage marks are 6 in. apart. The test specimen shall then be released within 5 seconds and the distance between gage marks shall be determined 1 minute after the beginning of release. The set is the difference between this length and the original 2-in. gage length.

AGING TESTS

Aging Test Conditions

34. (*a*) For the aging tests, nine test specimens of similar size and shape, sampled in accordance with Section 25, taken from the same length of insulation, shall be used; three for the determination of unaged properties, three for the oxygen bomb test and three for the Geer oven test.

(*b*) In the case of wire and cable smaller than No. 6 A.w.g. with an insulation thickness less than $\frac{3}{32}$ in., the insulation shall be heated in the oxygen bomb and in the Geer oven without removing the conductor.

(*c*) In the case of wire and cable of No. 6 A.w.g. and larger or with an insulation thickness greater than $\frac{3}{32}$ in., samples approximately square in section shall be cut from the insulation with a cross-section not greater than 0.025 sq. in.

(*d*) Die-cut samples shall be buffed before being subjected to the accelerated aging test wherever the thickness of the sample is $\frac{3}{32}$ in. or greater after buffing.

(*e*) The test specimens shall have no protective covering and shall be suspended vertically in such a manner that they will not come in contact with each other or with the sides of the bomb or oven.

(*f*) Physical tests on both aged and unaged specimens shall be made at the same time. The aged specimens shall have a rest period of not less than 16 hr. nor more than 48 hr. between the completion of the aging and the determination of the physical properties.

Oxygen Bomb Test

35. The test specimens shall be heated in an atmosphere of oxygen at a pressure of 300 lb. per sq. in. at a temperature of from 157 to 159° F. for a period of 96 hours. The weight of the rubber in the bomb shall not be over 2 g. per cu. in. of bomb space. The bomb pressure shall be reduced at a uniform rate, requiring at least two minutes, when specimens are removed. The bomb temperature shall be recorded automatically on a chart.

Geer Oven Test

36. The test specimens shall be heated at a temperature of from 157 to 159° F. for a period of 96 hours in an oven having a free circulation of fresh air. The oven temperature shall be recorded automatically on a chart.

RETESTS AND REJECTIONS

Retests

37. (*a*) *Tensile Strength, Tensile Stress, Set, Elongation Retests.*—When tested in accordance with Sections 30, 31, 32 and 33, if a specimen fails to conform to any one of the requirements for tensile strength, tensile stress, set, or elongation at rupture specified in Section 16, two additional specimens shall be taken from the same sample and the average of the results shall determine whether the material conforms to the requirements.

(*b*) *Aging Retests.*—Should the first set of specimens selected under Section 34 (*a*) fail to meet the specifications, two other sets of specimens shall be tested and if either of these sets fails, the coils, reels or lengths will be rejected.

Rejection

38. When ten or more samples are selected in any inspection lot, all coils, reels or lengths may be rejected if more than 10 per cent of the samples fail. If 10 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the results of such individual tests. Where the number of samples selected in any inspection lot is less than ten, all coils, reels or lengths shall be rejected if more than 20 per cent of the samples fail. If 20 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the result of such individual tests.

THICKNESS

Apparatus

39. The thickness measurements may be made with any type of micrometer reading to 0.001 in., suitable for measurements of this character.

Number of Measurements

40. Where the lot of wire to be inspected consists of two coils or reels or less, at least one determination of the thickness shall be made on each coil or reel. Where the lot consists of more than two coils or reels and less than 20 coils or reels, at least one determination of the thickness shall be made on each of two coils or reels taken at random. If the lot consists of 20 or more coils or reels, not less than

10 per cent of the coils or reels shall be selected at random and at least one determination of the thickness made on each coil or reel so selected.

Procedure

41. The average thickness of the insulation shall be taken as one-half the difference between the mean of the maximum and minimum diameters measured at any one point and the average diameter of the conductor measured at the same point. The minimum thickness shall be taken as the difference between a measurement made over the conductor plus the thinnest wall and the diameter of the conductor. (The first measurement is made by "slicing off" the heavier side of the insulation.)

TABLE VI.—TEMPERATURE COEFFICIENTS.

Temperature		Temperature Coefficient	Temperature		Temperature Coefficient
Deg. Fahrenheit	Deg. Centigrade		Deg. Fahrenheit	Deg. Centigrade	
46	7.8	0.69	61	16.1	1.03
47	8.3	0.71	62	16.7	1.05
48	8.9	0.73	63	17.2	1.08
49	9.4	0.75	64	17.8	1.11
50	10.0	0.77	65	18.3	1.14
51	10.6	0.79	66	18.9	1.17
52	11.1	0.81	67	19.4	1.20
53	11.7	0.83	68	20.0	1.23
54	12.2	0.85	69	20.6	1.26
55	12.8	0.88	70	21.1	1.30
56	13.3	0.90	71	21.7	1.33
57	13.9	0.92	72	22.2	1.37
58	14.4	0.94	73	22.8	1.40
59	15.0	0.97	74	23.3	1.44
60	15.6	1.00	75	23.9	1.48

In the case of multiple-conductor cable, the measurements shall be made on the individual wires before being cabled.

Rejection

42. If the thickness of the insulation of any coil or reel is found to be less than the specified value, that coil or reel shall be rejected and a thickness measurement on each of the remaining coils or reels shall be made.

ELECTRICAL TESTS

Place of Testing

43. Electrical tests of wire and cable shall be made at the place of manufacture.

High Voltage Test

44. The high voltage test shall be made with alternating potential from a transformer and generator of ample capacity and in no case

less than 5 kva. The frequency of the test voltage shall be not greater than 100 cycles and shall have a wave shape approximating as closely as possible a sine curve.

Rate of Application

45. The initially-applied voltage shall be not greater than the rated voltage and the rate of increase shall be approximately uniform and not over 100 per cent in 10 seconds nor less than 100 per cent in 60 seconds.

Immersion in Water

46. (*a*) The outer surface of the insulation of complete insulated wires and cables shall be grounded while being electrically tested. If the insulation is not provided with a conducting covering, and if the covering is not liable to injury by water, the ground shall be obtained by immersing the insulated wire or cable in water for at least 12 hours and testing at the end of that period while immersed. If the outer covering is susceptible to injury by immersion, the insulated conductor shall be tested before the application of such covering.

(*b*) In the case of multiple-conductor cables, without waterproof over-all jacket of insulation, no immersion test shall be made on finished cables, but only on the individual conductors before assembling.

Application of Voltage

47. (*a*) *Single-Conductor Cables.*—Single-conductor cables shall be tested between conductor and sheath or water in which they are immersed.

(*b*) *Multiple-Conductor Cables.*—If a multiple-conductor cable is rated at the same operating voltage between conductor and sheath or water as between conductors, each conductor shall be tested against the other conductors in the cable and against the sheath or water, at the test voltage prescribed for that rated voltage. If a cable is rated at a voltage between conductors and ground different from that between conductors, the test between conductors shall be based upon the rated voltage between conductors and the test between each conductor and sheath or water, shall be based on the rated voltage between conductors and sheath or water.

The several tests may be made by any arrangement of testing transformers suitable for the prescribed tests, such as one or more transformers supplied from a single-phase source or three transformers connected in star and supplied from a three-phase source.

Insulation Resistance

48. (*a*) The insulation resistance shall be measured after the high-voltage test has been made and while the wire or cable is still immersed in water. The measurement shall be made after one-minute electrification with a continuous e.m.f. of from 100 to 500 volts, the conductor being maintained negative to the water. The temperature of the water shall be within the limits given in Table VI.

Temperature Coefficient

(*b*) If the temperature at which the insulation resistance was measured differs from 60° F. (15.5° C.), the resistance shall be reduced to that at 60° F. (15.5° C.) by multiplying the measured value by the coefficient in Table VI corresponding to the temperature at which the measurement was made.

Moisture Absorption Test

49. (*a*) A 15-ft. sample with all the coverings removed shall be selected at random from the wire offered for inspection. The middle 10 ft. of the sample shall be immersed in distilled water for a period of 14 days with the $2\frac{1}{2}$-ft. portion at each end kept above the water as leakage insulation. The three measurements specified in Section 20 shall be taken with the water at the same temperature. The water shall be maintained at room temperature, but not less than 70 F. (21 C.).

(*b*) The specific inductive capacity of the insulation shall be determined at commercial frequencies and shall be calculated as follows:

$$\text{Specific inductive capacity} = 13{,}600\ C \log_{10} \frac{D}{d}$$

where C = the capacity in microfarads of 10 ft. of sample;
D = the diameter over insulation; and
d = the diameter over conductor.

The moisture absorption test shall be made only when requested by the purchaser.

(*C*) CABLE TAPE

Material

50. Cable tape shall be made from cotton cloth having a weight of not less than 1 lb. per 4 yd. with a width of 36 in. and not less than 56 by 60 picks per inch, and shall be frictioned on both sides and thoroughly filled with a rubber compound.

Application

51. The tape shall be applied helically and may be applied before vulcanization. The maximum width and minimum overlap shall conform to the values in Table VII.

Intermediate Diameters

52. For intermediate diameters the requirements shall be those of the next smaller diameter indicated in Table VII.

Number of Tests

53. Samples shall be taken at the option of the purchaser.

TABLE VII.—WIDTH AND OVERLAP OF RUBBER-FILLED CABLE TAPE.

DIAMETER OVER INSULATION, IN.	MAXIMUM WIDTH OF TAPE, IN.	MINIMUM OVERLAP, IN.
2.00	5	½
1.75	4½	½
1.50	4	½
1.25	3½	½
1.15	3¼	½
1.00	3	½
0.88	2¾	⅜
0.75	2⅜	⅜
0.62	2	⅜
0.50	1¾	⅜
0.38	1½	¼
0.31	1¼	¼
0.25	1	¼
0.19	⅞	⅛
0.16	¾	⅛

(*D*) COTTON BRAID

Braids

54. (*a*) Two types of cotton braid are covered in these specifications, namely, standard braid and heavy braid, as follows:

Standard Braid is designed for indoor service and installation in conduits.

Heavy Braid is designed for outdoor and rough service.

(*b*) Unless otherwise specified, standard braid shall be supplied under these specifications.

(*c*) In multiple conductor cables the individual conductors shall not be braid-covered unless specified.

Material

55. Cotton braid shall be closely woven from cotton thread having not less than two plies.

Construction

56. (*a*) The braid shall be so constructed that the tangent of the angle between the cotton thread and the side of the wire shall be not less than that specified in Table VIII.

TABLE VIII.—TANGENT OF ANGLE OF BRAID.

DIAMETER UNDER BRAID, IN.	VALUE OF TANGENT	CORRESPONDING BRAID ANGLE, DEG.
0 to 1.00	0.700	35
1.001 to 1.500	0.839	40
1.501 and over	1.000	45

(*b*) The thickness of standard braid shall be not less than that specified in Table IX and that of heavy braid not less than that specified in Table X.

TABLE IX.—MINIMUM THICKNESS OF STANDARD BRAID.

DIAMETER UNDER BRAID, IN.	MINIMUM THICKNESS OF BRAID, IN.	CORRESPONDING MINIMUM SIZE AND PLY OF COTTON YARN
0 to 0.200	0.0163	30/2
0.201 to 0.350	0.0175	26/2
0.351 to 0.800	0.0200	20/2
0.801 to 1.500	0.0258	12/2
1.501 to 3.000	0.0316	8/2

TABLE X.—MINIMUM THICKNESS OF HEAVY BRAID.

DIAMETER UNDER BRAID, IN.	MINIMUM THICKNESS OF BRAID, IN.	CORRESPONDING MINIMUM SIZE AND PLY OF COTTON YARN
0 to 0.200	0.020	20/2
0.201 to 0.300	0.0223	16/2
0.301 to 0.600	0.0258	12/2
0.601 to 1.000	0.0316	8/2
1.001 to 1.500	0.037	6/2
1.501 to 2.000	0.0446	4/2
2.001 to 3.000	0.0556	4/3

(*c*) The number of carriers and the number of ends per carrier used in applying the braid shall be optional providing all other limitations of Sections 55 and 56 are met. However, the picks per inch shall be not less than the value as calculated by the following formula:

$$P = \sqrt{\left[\frac{1}{tE + M}\right]^2 - \left[\frac{C}{2\pi\,(D + T)}\right]^2}$$

where P = the picks per inch;

T = the thickness of braid, in inches; $T = 2t$

t = the thickness of one end of cotton, in inches; $t = \dfrac{0.0279\,K}{\sqrt{S}}$

K = cabling factor for plied yarn; values of K are: $\begin{cases} 2 \text{ ply} = 1.60 \\ 3 \text{ ply} = 2.00 \\ 4 \text{ ply} = 2.36 \end{cases}$
S = the cotton ply, size or number;
E = the number of ends per carrier;
C = the number of carriers;
D = the diameter under braid, in inches;
M = the space between each set of carrier threads, in inches;

$$M = X\,(0.011 + 7.0\,t^2E^2)$$

X = the closeness constant $\left\{\right.$ Values of X:

	DIAMETER UNDER BRAID, IN.
1.1......	0 to 0.500
1.0......	0.501 and over

For convenience in calculating the more usual braid constructions, the formula for picks may be reduced to:

$$P = \sqrt{Y - \frac{Z}{(D+T)^2}} \text{ where } Y = \frac{1}{(tE+M)^2} \text{ and } Z = \left(\frac{C}{2\pi}\right)^2$$

Values of Y for some of the most commonly used cottons are:

Size of Yarn	Thickness of Braid, T	Values of Y										
		For Diameters Under 0.500 in.				For Diameters 0.501 in. and Over						
		2 End	3 End	4 End	5 End	2 End	3 End	4 End	5 End	6 End	7 End	8 End
30/2	0.0163................	1081	592	358	233	....	....	....	....	....	....	....
26/2	0.0175................	982	526	312	220	....	....	....	....	....	....	....
24/2	0.0182................	930	492	290	185	....	....	....	....	....	....	....
20/2	0.0200................	807	416	241	151	878	446	259	163	....	....	....
16/2	0.0223................	683	339	193	118	738	365	207	127	....	....	....
14/2	0.0238................	616	302	168	103	664	324	180	111	....	....	....
12/2	0.0258................	538	257	142	85	582	276	152	92	59	40	28
10/2	0.0282................	....	....	....	....	497	231	125	74	48	32	22
8/2	0.0316................	....	....	....	....	407	183	96	56	35	23	16

Values of Z for the standard braiders are:

NUMBER OF CARRIERS	VALUES OF Z
12..	3.65
16..	6.49
20..	10.13
24..	14.59
36..	32.80
48..	58.40

(*d*) For braid over twin wires use 1.64 times the conductor diameter to determine the proper braid.

(*e*) Where two braids are specified, the outer braid shall be determined by the diameter over the inner braid. Where the diameter change-over limit is such that Table IX or Table X and this section require different sizes of yarn on the inner and outer braids, both braids shall be of the size of yarn as required on the outer braid.

TABLE XI.—BRAID.

Diameter Under Braid, *D*, in.	Size and Ply of Cotton Yarn, Minimum	No. of Ends	Thickness of Braid, Minimum, in.	Diameter, Mean Avg. (*D*+*T*), in.	12-Carrier Braiders		16-Carrier Braiders		20-Carrier Braiders		24-Carrier Braiders		36-Carrier Braiders		48-Carrier Braiders	
					Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.	Picks per inch	Braid Angle, deg.
								STANDARD BRAID								
0.090	30/2	2	0.0163	0.106	27.7	57.0	22.6	43.0	....	....	....	....	....	....	....	....
0.091 to 0.110	30/2	2	0.0163	0.116	28.6	60.0	24.7	48.0	....	....	....	....	....	....	....	....
0.111 to 0.125	30/2	2	0.0163	0.134	29.8	65.0	27.0	55.0	23.0	44.0	....	....	....	....	....	....
0.126 to 0.150	30/2	2	0.0163	0.154	30.6	68.0	28.6	60.0	25.8	51.0	....	....	....	....	....	....
0.151 to 0.175	30/2	2	0.0163	0.179	31.2	71.0	29.8	64.0	27.8	58.0	....	....	....	....	....	....
0.176 to 0.200	30/2	2	0.0163	0.204	31.6	73.0	30.6	68.0	29.1	62.0	....	....	....	....	....	....
0.201 to 0.225	26/2	2	0.0175	0.231	30.2	74.3	29.3	69.4	28.1	63.9	26.6	58.1	....	....	....	....
0.226 to 0.250	26/2	2	0.0175	0.256	30.4	76.2	29.7	71.5	28.8	66.7	27.6	61.6	....	....	....	....
0.251 to 0.300	26/2	2	0.0175	0.293	30.4	78.0	30.2	74.0	29.5	70.0	28.6	65.0	....	....	....	....
0.301 to 0.350	26/2	2	0.0175	0.343	....	....	....	....	30.0	73.0	29.4	69.0	....	....	....	....
0.351 to 0.400	20/2	3	0.020	0.396	....	....	....	....	18.8	66.0	18.0	62.0	....	....	....	....
0.401 to 0.450	20/2	3	0.020	0.445	....	....	....	....	19.1	70.0	18.5	65.0	....	....	....	....
0.451 to 0.500	20/2	3	0.020	0.495	....	....	....	....	19.4	72.0	18.9	68.0	....	....	....	....
0.501 to 0.600	20/2	3	0.020	0.570	....	....	....	....	20.4	75.0	20.1	72.0	....	....	....	....
0.601 to 0.800	20/2	3	0.020	0.720	....	....	....	....	20.6	78.0	20.5	76.0	....	....	....	....
0.801 to 1.000	12/2	4	0.0258	0.925	....	....	....	....	11.8	73.7	11.6	70.3	10.7	59.8	9.2	48.0
1.001 to 1.200	12/2	4	0.0258	1.125	....	....	....	....	12.0	76.8	11.9	74.0	11.2	65.7	10.3	56.6
1.201 to 1.500	12/2	4	0.0258	1.376	....	....	....	....	....	....	12.0	77.0	11.6	70.2	11.0	63.2
1.501 to 2.000	8/2	5	0.0316	1.782	....	....	....	....	....	....	6.2	73.3	6.8	64.6	6.1	55.0
2,001 to 3.000	8/2	5	0.0316	2.532	....	....	....	....	....	....	7.3	78.2	7.1	72.2	6.9	66.2
								HEAVY BRAID								
0.090	20/2	2	0.020	0.110	22.6	52.5	16.5	35.5	....	....	....	....	....	....	....	....
0.091 to 0.110	20/2	2	0.020	0.120	23.6	56.0	18.9	41.7	....	....	....	....	....	....	....	....
0.111 to 0.125	20/2	2	0.020	0.138	24.6	58.3	21.5	49.3	....	....	....	....	....	....	....	....
0.126 to 0.150	20/2	2	0.020	0.158	25.7	64.6	23.3	55.3	20.0	44.8	....	....	....	....	....	....
0.151 to 0.175	20/2	2	0.020	0.183	26.4	67.5	24.8	60.5	22.7	52.5	19.2	42.5	....	....	....	....
0.176 to 0.200	20/2	2	0.020	0.208	26.9	70.4	27.5	65.8	23.7	57.0	21.6	49.5	....	....	....	....
0.201 to 0.225	16/2	2	0.0223	0.235	....	....	23.8	56.5	22.4	58.8	20.4	51.5	....	....	....	....
0.226 to 0.250	16/2	2	0.0223	0.260	....	....	25.8	77.8	23.0	62.0	21.6	55.6	....	....	....	....
0.251 to 0.300	16/2	3	0.0223	0.297	....	....	16.3	62.3	15.0	54.5	13.2	49.5	....	....	....	....
0.301 to 0.350	12/2	3	0.0258	0.351	....	....	....	....	13.2	55.4	11.8	47.3	....	....	....	....
0.351 to 0.400	12/2	3	0.0258	0.401	....	....	....	....	13.9	60.1	12.9	53.5	....	....	....	....
0.401 to 0.450	12/2	3	0.0258	0.451	....	....	....	....	14.4	63.9	13.6	58.1	....	....	....	....
0.451 to 0.500	12/2	3	0.0258	0.501	....	....	....	....	14.7	66.6	14.1	62.0	....	....	....	....
0.501 to 0.600	12/2	3	0.0258	0.576	....	....	....	....	....	....	15.2	66.4	13.3	55.7	....	....
0.601 to 0.800	8/2	3	0.0316	0.732	....	....	....	....	....	....	12.5	67.3	11.1	57.2	....	....
0.801 to 1.000	8/2	3	0.0316	0.932	....	....	....	....	....	....	12.9	72.3	12.0	65.0	10.8	53.0
1.001 to 1.200	6/2	2	0.037	1.137	....	....	....	....	....	....	....	....	17.0	74.9	16.4	67.7
1.201 to 1.500	6/2	2	0.037	1.387	....	....	....	....	....	....	....	....	17.2	77.7	16.8	71.8
1.501 to 2.000	4/2	3	0.0446	1.795	....	....	....	....	....	....	....	....	8.6	71.3	8.1	62.3
2.001 to 3.000	4/3	3	0.0556	2.556	....	....	....	....	....	....	....	....	6.6	72.8	6.3	64.5

(*f*) Where two braids are applied in one operation, these specifications shall apply to the inner and outer braids except that picks per inch and angle of braid for inner braid shall be governed by the construction of the machine.

(*g*) These specifications do not apply to braids for fixture wire or to fancy or special braids.

(*h*) In Table XI are tabulated the required picks per inch as calculated by the formula in Paragraph (*c*) and the corresponding braid angle for braids applied with the minimum size and ply of cotton, and a definite number of ends per carrier. However, it is not the intent of these specifications to limit the braids to the scope of Table XI since heavier cottons or a variation in ends per carrier are permissible providing all requirements of Sections 55 and 56 are fulfilled.

Measurements

57. The various quantities shall be determined as follows:

Diameter Under Braid, by a suitable micrometer reading.

Number of Carriers and *Ends per Carrier*, by examination of braid.

Picks per Inch, on a 4-in. sample after wiping off outside of braid with chloroform.

Angle of Braid by formula: Tangent of Angle $= \dfrac{2\pi P\,(D + T)}{C}$

Thickness of Braid (2 × diameter of single end of cotton), by measuring 25 per cent of the total number of threads with a paper micrometer having a foot 0.4 in. in diameter under a pressure of 50 g. The sample of braid on which the average diameter is determined shall be prepared by immersing a 2-in. length of sample in chloroform in a suitable container for 5 minutes, decanting and repeating for 1 minute, and removing and drying it thoroughly by pressing it between cheese cloth.

Number of Tests

58. Samples shall be taken at the option of the purchaser.

(*E*) FINISH

Finish

59. The braid shall be completely saturated with a weather-resisting compound and finished with a black moisture-resistant compound, thoroughly slicked down.

Saturating and Finishing Compounds

60. The saturating and finishing compounds shall have no injurious effect upon the rubber insulation or the coverings during application and shall meet the following tests:

(*a*) *Moisture Absorption Test.*—A 6-in. sample of wire with carefully paraffined ends shall be weighed and submerged in fresh water of a temperature of 20° C. (68° F.) for a period of 24 hr. The increase in weight after submersion and removal of surface water shall be not more than 9 per cent of the weight exclusive of copper and insulation before submersion.

(*b*) *Melt Test.*—A 6-in. sample of wire with the insulation removed for ½ in. at each end shall be placed on clean, white glazed paper and maintained at 52° C. (125° F.) for 30 minutes. The compound shall not migrate sufficiently to be transferred to the paper or form a ridge perceptible to the finger upon it.

(*F*) LEAD SHEATHS

Composition

61. Lead sheaths shall consist of commercially pure lead (approximately 99.85 per cent) without flaws and tightly formed about the taped core of the cable.

TABLE XII.—THICKNESS OF LEAD SHEATHS.

DIAMETER OF CORE, IN.[a]	THICKNESS OF SHEATH IN SIXTY-FOURTHS OF AN INCH
Over 3.000	9
2.001 to 3.000	8
1.501 to 2.000	7
1.051 to 1.500	6
0.701 to 1.050	5
0.426 to 0.700	4
0.000 to 0.425	3

---

[a] For twin cables, use the major axis.

Thickness

62. Lead sheaths shall have an average thickness not less than that indicated in Table XII and the minimum thickness shall in no place be less than 90 per cent of the required average thickness.

Measurement

63. A short section of the lead sheath shall be removed from the wire or cable and the thickness measured with a suitable micrometer caliper at not less than ten points, approximately equally spaced, care being taken to include the thinnest and the thickest parts.

(*G*) INSPECTION AND REJECTION

Inspection and Test

64. (*a*) Inspection shall be made prior to shipment and at the place of manufacture.

(*b*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the wire or cable to permit of arrangement of inspection.

(*c*) The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the wire ordered, except compounding room. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the wire is being furnished in accordance with these specifications.

(*d*) The purchaser at his option may make the various tests on samples in his own laboratory or elsewhere, but such tests shall be made at the expense of the purchaser.

Rejection

65. Each coil, reel or length which fails to comply with the physical and electrical requirements of these specifications shall be rejected.

Rehearing

66. Samples of rejected material shall be preserved for two weeks from date of test report. In case of dissatisfaction with the results of test, the manufacturer may make claim for a rehearing within that time. Sealed duplicate samples may be retained by the manufacturer at his option.

APPENDIX I

ANNEALED COPPER STANDARD[1]

The following shall be taken as normal values for standard annealed copper:

(*a*) *Resistance.*—At a temperature of 20° C. the resistance of a wire of standard annealed copper 1 meter in length and of a uniform section of 1 sq. mm. is $\frac{1}{58}$ ohm = 0.017241 ohm.

(*b*) *Density.*—At a temperature of 20° C. the density of standard annealed copper is 8.89 g. per cu. cm.

(*c*) *Temperature Coefficient of Resistance.*—At a temperature of 20° C. the "constant mass" temperature coefficient of resistance of standard annealed copper, measured between two potential points rigidly fixed to the wire, is 0.00393 = 1/254.45 per degree Centigrade.

(*d*) Other values of resistivity of standard annealed copper at 20° C. deduced from Paragraphs (*a*) and (*b*) are as follows:

Resistance of a wire of uniform section, 1 meter long and weighing 1 g. = 0.15328 ohm.

---

[1] Extracts from American Institute of Electrical Engineers' Standard No. 30 (1932).

Resistance of a wire with a uniform section of 1 cir. mil and 1 ft. long = 10.371 ohm.

Resistance between opposite faces of 1 cu. cm. = 1.7241 microhm.

Resistance between opposite faces of 1 cu. in. = 0.67879 microhm.

APPENDIX II

INTERPRETATION OF INSULATION THICKNESSES OF TABLE IV

For series-street-lighting cable, use the following procedure:

(*a*) If the transformer is not equipped with protectors, use the open circuit secondary voltage of the transformer as rated voltage of the cable and select the proper wall thickness from Table IV under the rated circuit voltage column headed "Grounded."

(*b*) If the transformer is equipped with protectors, use the closed or loaded secondary voltage of the transformer as the rated circuit voltage of the cable and select the proper wall thickness from Table IV under the column headed "Grounded."

NOTE.—It is preferable, both in Paragraphs (*a*) and (*b*) above, to select a cable with a higher voltage rating than obtained using the above procedure, both as a measure of safety and to allow the substitution of a larger transformer without necessitating the replacement of the cable.

The thickness of insulation for the various systems shall be determined as follows:

(*a*) For three-phase systems with grounded or ungrounded neutral, use thickness values in accordance with the respective columns in Table IV.

(*b*) For single or two-phase systems up to and including 5000 v., use thickness values in accordance with the grounded column of Table IV.

(*c*) For single or two-phase systems operating at over 5000 v. with one side grounded, multiply the circuit voltage (phase-to-phase) by 1.73 and use the resulting voltage value to select the corresponding insulation thickness in the grounded column of Table IV.

(*d*) For single or two-phase systems operating at over 5000 v. with the center grounded, multiply the circuit voltage (phase-to-phase) by 0.866 ($= \frac{1}{2}\sqrt{3}$) and use the resulting voltage value to select the corresponding insulation thickness in the grounded column of Table IV.

(*e*) For non-leaded submarine cables, $\frac{1}{32}$ in. should be added to the specified respective walls of insulation in Table IV for all sizes and voltages.

TENTATIVE SPECIFICATIONS

FOR

INSULATED WIRE AND CABLE: CLASS A, 30 PER CENT HEVEA RUBBER COMPOUND[1]

A.S.T.M. Designation: D 393 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. (*a*) These specifications cover wires and cables conforming to the Tentative Specifications for Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (A.S.T.M. Designation: D 27 – 34 T) of the American Society for Testing Materials,[2] except that Class A rubber compound shall be substituted for Class AO rubber compound.

(*b*) The Class A compound shall conform to the chemical and physical requirements of these specifications.

MANUFACTURE

Composition

2. (*a*) Class A rubber compound shall contain exclusively not less than 30 per cent nor more than 33 per cent of the best quality Hevea rubber which has not previously been used in a rubber compound, solid waxy hydrocarbons, suitable mineral matter and sufficient sulfur to properly vulcanize the compound.

(*b*) The mineral matter shall be dry and free from organic materials.

(*c*) The waxy hydrocarbons used shall be solid at 54 C. and shall be free from saponifiable matter.

(*d*) Contamination of the compound, such as by the use of impregnated tapes, will not excuse the manufacturer from conforming to these specifications.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

These specifications were formerly part of the Tentative Specifications for Insulated Wire and Cable: 30 per cent Hevea Rubber (D 27 – 33 T) and were issued separately under the present designation in 1934.

[2] See p. 1101.

CHEMICAL PROPERTIES

Quantitative Requirements

3. The insulation after vulcanization shall conform on analysis to the following requirements expressed as percentages by weight of the whole sample:

	MAXIMUM	MINIMUM
Rubber, per cent	33	30
Waxy hydrocarbons, per cent	4	..
Free sulfur, per cent	0.7	..

	30 PER CENT RUBBER[a]		33 PER CENT RUBBER[a]	
	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
Saponifiable acetone extract, per cent	1.35	0.55	1.50	0.60
Unsaponifiable resins, per cent	0.45	....	0.50	....
Chloroform extract, per cent	0.90	....	1.00	....
Alcoholic potash extract, per cent	0.55	....	0.60	....
Total sulfur, per cent	2.10	....	2.30	....

---

[a] For percentages between 30 and 33, the limits shall be in proportion to the percentage of rubber found.

Qualitative Requirements

4. (*a*) The acetone solution shall not fluoresce and the acetone extract (60 ml.) shall be not darker than a light straw color.

(*b*) The hydrocarbons shall be solid, waxy and not darker than a light brown.

(*c*) The chloroform extract (60 ml.) shall not be darker than a straw color.

PHYSICAL PROPERTIES

Physical Properties

5. The insulation shall conform to the following requirements as to physical properties:

Tensile strength, min., lb. per sq. in.		1000
Tensile stress at 200 per cent elongation, min., lb. per sq. in.		300
Set in 2-in. gage length, max., in.		$\frac{3}{8}$
Elongation at rupture, min., per cent		350
Specific gravity, min.	30 per cent rubber	1.75[b]
	33 per cent rubber	1.67[b]

---

[b] For percentages between 30 and 33, the specific gravity limits shall be in proportion to the percentage of rubber found.

METHODS OF TESTING

Methods of Testing

6. The chemical and physical properties specified shall be determined in accordance with the methods of testing described in Sections 21 to 50 of the Tentative Specifications for Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (A.S.T.M. Designation: D 27 – 34 T) of the American Society for Testing Materials.[1]

---

[1] See p. 1108.

TENTATIVE SPECIFICATIONS
FOR
INSULATED WIRE AND CABLE: PERFORMANCE RUBBER COMPOUND[1]

A.S.T.M. Designation: D 353 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1932; REVISED, 1933, 1934.[2]

Scope. 1. (*a*) These specifications cover wire and cable insulated with a vulcanized rubber compound. The suitability of the compound as insulation shall be determined solely by physical and electrical tests. The compound shall be called performance rubber compound.

(*b*) Except for the rubber insulation and methods of testing, wire and cable supplied under these specifications shall conform to the Tentative Specifications for Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (A.S.T.M. Designation: D 27 - 34 T) of the American Society for Testing Materials.[3]

INSULATION

Workmanship. 2. (*a*) The insulation shall be homogeneous in character, tough, elastic and applied concentrically about the conductor and shall fit tightly thereto. Where the insulation is applied in more than one layer adjacent layers shall be vulcanized into a homogeneous mass.

(*b*) The insulation of braided wires up to No. 7 A. w. g., inclusive, shall be covered with a single cotton braid. On larger sizes the fibrous covering shall consist of a cable tape and cotton braid or two cotton braids. The cable tape may be applied before vulcanization. In multiple conductor cables the individual conductors shall not be braid-covered unless specified.

(*c*) Where repairs or joints are made in the insulation, the work shall be done in such manner that the repaired part of the joint, and all parts affected in the process, shall be as strong and durable electrically and mechanically as the remainder of the insulation and shall not exceed the limitations on the thickness specified in Section 5.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

[3] See p. 1101.

MANUFACTURE

Composition. 3. The insulation shall consist of a properly vulcanized rubber compound that will meet the tests hereinafter specified.

PHYSICAL PROPERTIES

Physical Properties. 4. The insulation shall conform to the following requirements as to physical properties:

	MAXIMUM	MINIMUM
Tensile strength, lb. per sq. in.	..	1200
Tensile stress at 200 per cent elongation, lb. per sq. in.	..	300
Elongation at rupture, per cent	..	400
Set in 2-in. gage length, in.	$\frac{3}{8}$	....
Depreciation in tensile strength and elongation after oxygen bomb test, per cent	25	....
Depreciation in tensile strength and elongation after Geer oven test, per cent	15	....

THICKNESS

Thickness. 5. (*a*) The average thickness of the insulation shall be not less than that given in Table I. The thickness of the insulation at the thinnest part shall be not more than 10 per cent less than the specified thickness, but in no case shall such 10 per cent allowance exceed 0.031 in.

(*b*) The thicknesses in Table I apply to single conductor cable and the individual conductors of multiple conductor cables, leaded or braided, except special applications such as aerial, non-leaded submarine, and vertical riser cable.

NOTE.—In Appendix I will be found an interpretation of the insulation thicknesses given in Table I.

ELECTRICAL PROPERTIES

High Voltage Test. 6. Each coil, reel, or length of wire or cable after vulcanization and before the application of any covering other than tape used in vulcanization shall successfully withstand the application of an alternating voltage of not less than that given in Table I for a period of 5 minutes.

Insulation Resistance. 7. Each coil, reel, or length of wire or cable after being subjected to the high voltage test specified in Section 6 shall have an insulation resistance not less than that given in Table II.

Moisture Absorption. 8. (*a*) The increase in the specific inductive capacity of the insulation shall be used as an indication of the amount of moisture absorbed.

TABLE I.—THICKNESS OF INSULATION AND ALTERNATING TEST VOLTAGE (SEE NOTE 3).

NOTE 1.—Rated circuit voltage of alternating-current circuits is the phase-to-phase voltage.

NOTE 2.—For an intermediate size of wire or an intermediate rated circuit voltage the thickness and test voltage shall be that for the next larger size or higher rated circuit voltage.

NOTE 3.—For d. c. systems over 2000 volts consult the manufacturer. Above 5000 volts, a. c. special high-voltage rubber compounds are preferred according to the manufacturer's recommendations.

NOTE 4.—In voltage groups from 6001 to 7000 volts, and 7001 to 8000 volts, size No. 8 wire with the same insulation as No. 7 wire is allowable for series street lighting service.

Rated Circuit Voltage	Size of Conductor, A. w. g. Numbers or Circular Mils	Insulation Thickness on each Conductor, sixty-fourths of an inch		Test Voltage, kv.	
		Grounded	Ungrounded	Grounded	Ungrounded
0 to 600	No. 14 to No. 9	3	3	3	3
	No. 8 to No. 2	4	4	3.5	3.5
	No. 1 to No. 0000	5	5	4	4
	225 000 to 500 000 cir. mils	6	6	5	5
	525 000 to 1 000 000 cir. mils	7	7	6	6
	Over 1 000 000 cir. mils	8	8	7	7
601 to 1000	No. 14 to No. 8	4	4	4	4
	No. 7 to No. 2	5	5	5	5
	No. 1 to No. 0000	6	6	6	6
	225 000 to 500 000 cir. mils	7	7	7	7
	525 000 to 1 000 000 cir mils	8	8	8	8
	Over 1 000 000 cir. mils	9	9	9	9
1001 to 2000	No. 14 to No. 8	5	5	5	5
	No. 7 to No. 2	6	6	6	6
	No. 1 to No. 0000	7	7	7	7
	225 000 to 500 000 cir. mils	8	8	8	8
	525 000 to 1 000 000 cir. mils	9	9	9	9
	Over 1 000 000 cir. mils	9	9	9	9
2001 to 3000	No. 14 to No. 8	7	7	7	7
	No. 7 to No. 2	8	8	8	8
	No. 1 to No. 0000	8	8	8	8
	225 000 to 500 000 cir. mils	9	9	9	9
	525 000 to 1 000 000 cir. mils	9	9	9	9
	Over 1 000 000 cir. mils	10	10	10	10
3001 to 4000	No. 14 to No. 8	9	9	9	9
	No. 7 to No. 2	9	9	9	9
	No. 1 to No. 0000	9	9	9	9
	225 000 to 500 000 cir. mils	10	10	10	10
	525 000 to 1 000 000 cir. mils	10	10	10	10
	Over 1 000 000 cir. mils	11	11	11.5	11.5
4001 to 5000	No. 14 to No. 8	10	10	10	10
	No. 7 to No. 2	10	10	10	10
	No. 1 to No. 0000	10	10	10	10
	225 000 to 500 000 cir. mils	11	11	11.5	11.5
	525 000 to 1 000 000 cir. mils	11	11	11.5	11.5
	Over 1 000 000 cir. mils	12	12	13	13
5001 to 6000	No. 14 to No. 8	10	12	10	13
	No. 7 to No. 2	10	12	10	13
	No. 1 to No. 0000	10	12	10	13
	225 000 to 500 000 cir. mils	11	12	11.5	13
	525 000 to 1 000 000 cir. mils	11	12	11.5	13
	Over 1 000 000 cir. mils	12	13	13	14.5
6001 to 7000	No. 7 to No. 2	11	14	11.5	16
	No. 1 to No. 0000	11	14	11.5	16
	225 000 to 500 000 cir. mils	11	14	11.5	16
	525 000 to 1 000 000 cir. mils	11	14	11.5	16
	Over 1 000 000 cir. mils	12	15	13	17.5
7001 to 8000	No. 7 to No. 2	12	16	13	19
	No. 1 to No. 0000	12	16	13	19
	225 000 to 500 000 cir. mils	12	16	13	19
	525 000 to 1 000 000 cir. mils	12	16	13	19
	Over 1 000 000 cir. mils	13	17	14.5	20.5

(*b*) The specific inductive capacity after 24-hr. immersion in water shall not exceed six. The increase between the ends of the first and the fourteenth days shall not exceed 20 per cent and that between the ends of the seventh and fourteenth days, 5 per cent.

(*c*) The specific inductive capacity shall be determined at either 1000 or 60 cycles. Where measured at 1000 cycles, the voltage impressed upon the conductor shall not exceed 10 volts. Where measured at 60 cycles, the voltage impressed upon the conductor shall be equivalent to a stress of between 30 to 40 volts per mil of insulation.

(*d*) The measurements shall be made as described in Section 32.

METHODS OF TESTING

TENSILE STRENGTH, SET, AND ELONGATION AT RUPTURE

Sampling.

9. (*a*) Wire up to and including 250,000 cir. mils in size shall be sampled in accordance with the following requirements:

	NUMBER OF SAMPLES
2000 ft. and under	none
2001 to 10,000 ft.	1 for each 2000 ft. or fraction thereof
10,001 to 100,000 ft.	5 plus 1 for each 10,000 ft. additional over 10,000 ft.
100,001 to 500,000 ft.	14 plus 1 for each 25,000 ft. over 100,000 ft.

(*b*) For wire larger than 250,000 cir. mils, one sample shall be selected from quantities between 1000 and 2000 ft. and for larger quantities double those specified in Paragraph (*a*).

Test Specimen.

10. (*a*) *Size.*—For the physical tests, the test specimen may be the entire cross-section of the insulation in the case of small wires, or, in the case of a large wire or cable, either a segment or sector cut with a sharp knife held tangentially to the conductor or a shaped specimen cut out with a standard die. The test specimen shall be as free as possible from surface incisions and imperfections. There shall be no limit to the cross-section of the test specimen, except as restricted by the capacity of the testing machine.

NOTE.—The removal of the rubber insulation can be greatly accelerated and in most cases a test specimen which is an entire cross-section can be obtained free from surface incisions and imperfections by means of metallic mercury. The mercury should be introduced at one end of the sample between the insulation and the tinned surface of the conductor, and the sample inclined on a support with the end to which the mercury is applied at the top. The separation of the rubber insulation results from the amalgamation of the tin of the conductor with the mercury. The amalgamation is assisted by first immersing and rubbing the tinning on the exposed end of the conductor in the mercury.

(*b*) *Condition and Age.*—Specimens shall not be heated, immersed in water or subjected to any mechanical or chemical treatment not specifically prescribed in these specifications.

Specimens for accelerated aging tests shall be taken from the completed wire after the application of the specified covering and shall be aged with all such covering removed.

TABLE II.—INSULATION RESISTANCE, MEGOHMS-1000 FT. AT 60° F. (15.5° C.).

NOTE 1.—This table is based on a constant, $K = 21\,120$ in the following formula:

$R = K \log_{10}\frac{D}{d}$; where R = resistance in megohms-1000 ft., K = constant,

D = diameter over insulation, on each conductor, and d = diameter over conductor.

NOTE 2.—For an intermediate size, the insulation resistance shall be that of the next larger size.

Size of Conductor, A. w. g. Numbers or Circular Mils	Thickness of Insulation in Sixty-fourths of an Inch							
	2	3	4	5	6	7	8	10
No. 18	8400	10 800	....	....	....	....	....	....
No. 16	7400	9 500	....	....	....	....	....	....
No. 14	....	8 100	9 800	11 400	12 400	13 500	14 000	16 100
No. 12	....	7 100	8 400	9 800	10 800	11 900	12 700	14 500
No. 10	....	6 050	7 150	8 400	9 500	10 600	11 400	12 700
No. 8	....	4 500	5 550	6 600	7 650	8 700	9 200	10 800
No. 6	....	....	4 500	5 550	6 350	7 150	7 650	9 200
No. 4	....	....	3 950	4 500	5 300	6 050	6 600	7 650
No. 2	....	....	3 450	3 950	4 500	5 000	5 550	6 600
No. 1	....	....	3 150	3 450	3 950	4 500	5 300	6 050
No. 0	....	....	....	3 150	3 700	4 200	5 000	5 550
No. 00	....	....	....	2 900	3 450	3 950	4 500	5 000
No. 000	....	....	....	2 650	3 150	3 450	3 950	4 500
No. 0000	....	....	....	2 400	2 900	3 150	3 450	4 200
250 000 cir. mils	....	....	....	2 100	2 500	3 050	3 300	3 850
350 000 cir. mils	....	....	....	1 850	2 250	2 500	2 750	3 550
500 000 cir. mils	....	....	....	1 600	2 000	2 100	2 500	3 050
750 000 cir. mils	....	....	....	....	....	1 700	2 100	2 500
1 000 000 cir. mils	....	....	....	....	....	1 600	1 700	2 100
1 250 000 cir. mils	....	....	....	....	....	....	1 700	2 000
1 500 000 cir. mils	....	....	....	....	....	....	1 600	1 700
1 750 000 cir. mils	....	....	....	....	....	....	1 450	1 600
2 000 000 cir. mils	....	....	....	....	....	....	1 050	1 450

Size of Conductor, A. w. g. Numbers or Circular Mils	Thickness of Insulation in Sixty-fourths of an Inch			
	12	14	16	18
No. 14	17 700	....	....	....
No. 12	15 800	....	....	....
No. 10	14 000	....	....	....
No. 8	11 600	12 700	13 700	14 500
No. 6	10 300	11 100	12 100	12 900
No. 4	8 700	9 800	10 600	11 400
No. 2	7 650	8 400	9 000	9 800
No. 1	7 150	7 650	8 400	9 200
No. 0	6 350	7 150	7 900	8 400
No. 00	5 550	6 600	7 150	7 900
No. 000	5 300	6 050	6 600	7 150
No. 0000	5 000	5 550	6 050	6 600
250 000 cir. mils	4 600	5 300	5 800	6 350
350 000 cir. mils	4 100	4 500	5 000	5 550
500 000 cir. mils	3 550	3 950	4 500	4 750
750 000 cir. mils	2 750	3 300	3 700	4 100
1 000 000 cir. mils	2 500	2 900	3 300	....
1 250 000 cir. mils	2 250	2 650	3 050	....
1 500 000 cir. mils	2 100	2 500	....	....
1 750 000 cir. mils	2 000	2 400	....	....
2 000 000 cir. mils	1 700	2 250	....	....

No tests shall be made within 24 hours nor later than 60 days after vulcanization unless agreed to by the manufacturer.

(*c*) *Buffing.*—In the event of any irregularities on the surface of the test specimen, it shall be made smooth and of uniform thickness within 5 per cent of the original thickness by buffing, except when large strands are used, in which case the rubber sample shall be buffed sufficiently to remove all corrugations.

Calculation of Area.

11. Calculation of the area of the test specimens shall be made as follows:

(*a*) Where the total cross-section of the insulation is used, the area shall be taken as the difference between the area of the circle whose diameter is the average outside diameter of the insulation and the area of the conductor. The area of the stranded conductor shall be calculated from its maximum diameter.

(*b*) Where a segment or sector of the insulation has to be taken in the case of a large wire or cable or where the insulation is thin, the area shall be calculated as the thickness times the width. (This applies either to a straight test specimen or one stamped out with a die, and assumes that corrugations have been removed by buffing.)

Temperature at Test.

12. Physical tests shall be made at a room temperature not less than 65° F. (18.3° C.) nor more than 90° F. (32.2° C.) and the test specimen shall have been kept at the room temperature not less than 30 minutes prior to the test.

Tension Testing Machine.

13. The tension testing machine shall be power-driven and preferably of the pendulum type. The machine shall be accurate within 1 per cent of the breaking load. A spring balance type of apparatus may be used if provided with a device which will indicate the actual maximum load at which rupture takes place and if provision is made to prevent recoil of the spring.

Tensile Strength Tests.

14. The tensile strength test shall be made on a specimen which has not been previously stretched. The specimen shall have a length of not less than 6 in., and shall be marked with gage marks 2 in. apart and placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. The specimen shall be stretched at the rate of 20 in. per minute (jaw speed) until it breaks. The test specimen shall break between the gage marks. The tensile strength shall be calculated upon the area of the original specimen.

Tensile Stress Test.

15. The tensile stress test shall be made simultaneously with the tensile strength test by recording the load when the 2-in. gage length marks are 6 in. apart, that is, at 200 per cent elongation. The tensile stress shall be calculated upon the area of the original specimen.

Elongation at Rupture.

16. Elongation at rupture shall be determined simultaneously with the tensile strength test by reading the distance in inches between gage marks at the breaking point. The elongation at rupture shall be taken as the distance between gage marks at rupture less 2 in.

(the original gage length). The percentage of elongation at rupture is the elongation in inches divided by the original gage length (2 in.) and multiplied by 100 to express as a percentage.

Set Test. 17. The set test shall be made on a separate test specimen having a length of not less than 6 in. and marked with gage marks 2 in. apart. The specimen shall be placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. and shall be stretched at the rate of 20 in. per minute (jaw speed) until the gage marks are 6 in. apart. The test specimen shall then be released within 5 seconds and the distance between gage marks shall be determined 1 minute after the beginning of release. The set is the difference between this length and the original 2-in. gage length.

AGING TESTS

Aging Test Conditions. 18. (*a*) For the aging tests, nine test specimens, of similar size and shape, sampled in accordance with Section 9 taken from the same length of insulation shall be used; three for the determination of unaged properties, three for the oxygen bomb test and three for the Geer oven test.

(*b*) In the case of wire and cable smaller than No. 6 A.w.g. with an insulation thickness less than $\frac{3}{32}$ in., the insulation shall be heated in the oxygen bomb and in the Geer oven without removing the conductor.

(*c*) In the case of wire and cable of No. 6 A.w.g. and larger or with an insulation thickness greater than $\frac{3}{32}$ in., samples approximately square in section shall be cut from the insulation with a cross-section not greater than 0.025 sq. in.

(*d*) Die-cut samples shall be buffed before being subjected to the accelerated aging test wherever the thickness of the sample is $\frac{3}{32}$ in. or greater after buffing.

(*e*) The test specimens shall have no protective covering and shall be suspended vertically in such a manner that they will not come in contact with each other or with the sides of the bomb or oven.

(*f*) Physical tests on both the aged and unaged specimens shall be made at the same time. The aged specimens shall have a rest period of not less than 16 hours nor more than 48 hours between the completion of the aging test and determination of physical properties.

(*g*) Should the first set of specimens selected under Paragraph (*a*) fail to meet the specifications, two other sets of specimens shall be tested and if either of these sets fails, the coils, reels or lengths will be rejected.

Oxygen Bomb Test. 19. The test specimens shall be heated in an atmosphere of oxygen at a pressure of 300 lb. per sq. in. at a temperature of from 157 to 159° F. for a period of 96 hours. The weight of the rubber in the bomb shall not be over 2 g. per cu. in. of bomb space. The bomb pressure shall be reduced at a uniform rate, requiring at least two minutes, when specimens are removed. The bomb temperature shall be recorded automatically on a chart.

Geer Oven Test. 20. The test specimens shall be heated at a temperature of from 157 to 159° F. for a period of 96 hours in an oven having a free circulation of fresh air. The oven temperature shall be recorded automatically on a chart.

Rejection. 21. Where ten or more samples are selected in any inspection lot, all coils, reels or lengths shall be rejected if more than 10 per cent of the samples fail. If 10 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the results of such individual tests. Where the number of samples selected in any inspection lot is less than ten, all coils, reels or lengths shall be rejected if more than 20 per cent of the samples fail. If 20 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the results of such individual tests.

THICKNESS MEASUREMENTS

Apparatus. 22. The thickness measurements may be made with any type of micrometer reading to 0.001 in., suitable for measurements of this character.

Number of Measurements. 23. Where the lot of wire to be inspected consists of two coils or reels or less, at least one determination of the thickness shall be made on each coil or reel. Where the lot consists of more than two coils or reels and less than 20 coils or reels, at least one determination of the thickness shall be made on each of two coils or reels taken at random. If the lot consists of 20 or more coils or reels, not less than 10 per cent of the coils or reels shall be selected at random and at least one determination of the thickness made on each coil or reel so selected.

Procedure. 24. The average thickness of the insulation shall be taken as one-half the difference between the mean of the maximum and minimum diameters measured at any point and the average diameter of the conductor measured at the same point. The minimum thickness shall be as taken the difference between a measurement made over the conductor plus the thinnest wall and the diameter of the conductor. (The first measurement is made by "slicing off" the heavier side of the insulation.)

In the case of multiple-conductor cable, the measurements shall be made on the individual wires before being cabled.

Rejection. 25. If the thickness of the insulation of any coil or reel is found to be less than the specified value, that coil or reel shall be rejected and a thickness measurement on each of the remaining coils or reels shall be made.

ELECTRICAL TESTS

Place. 26. Electrical tests of wire and cable shall be made at the place of manufacture.

High Voltage Test. 27. The high voltage test shall be made with alternating potential from a transformer and generator of ample capacity and in no case less than 5 kva. The frequency of the test voltage shall be not greater than 100 cycles and shall have a wave shape approximating as closely as possible a sine curve

Rate of Application. 28. The initially applied voltage shall be not greater than the rated voltage and the rate of increase shall be approximately uniform and not over 100 per cent in 10 seconds nor less than 100 per cent in 60 seconds.

Grounding. 29. (*a*) The outer surface of the insulation of complete insulated wires and cables shall be grounded while being electrically tested. If the insulation is not provided with a conducting covering, and if the covering is not liable to injury by water, the ground shall be obtained by immersing the insulated wire or cable in water for at least 12 hours and testing at the end of that period while immersed. If the outer covering is susceptible to injury by immersion, the insulated conductor shall be tested before the application of such covering.

(*b*) In the case of multiple-conductor cables, without waterproof over-all jacket of insulation, no immersion test shall be made on finished cables, but only on the individual conductors before assembling.

Application of Voltage. 30. (*a*) *Single-Conductor Cables.*—Single-conductor cables shall be tested between conductor and sheath or water in which they are immersed.

(*b*) *Multiple-Conductor Cables.*—If a multiple-conductor cable is rated at the same operating voltage between conductor and sheath or water as between conductors, each conductor shall be tested against the other conductors in the cable and against the sheath or water, at the test voltage prescribed for that rated voltage. If a cable is rated at a voltage between conductors and ground different from that between conductors, the test between conductors shall be based upon the rated voltage between conductors and the test between each conductor and sheath or water, shall be based on the rated voltage between conductors and sheath or water.

The several tests may be made by any arrangement of testing transformers suitable for the prescribed tests, such as one or more transformers supplied from a single-phase source or three transformers connected in star and supplied from a three-phase source.

Insulation Resistance. 31. (*a*) The insulation resistance shall be measured after the high voltage test has been made and while the wire or cable is still immersed in water. The measurement shall be made after one minute electrification with a continuous e.m.f. of from 100 to 500 volts, the conductor being maintained negative to the water. The temperature of the water shall be within the limits given in Table III.

Temperature Coefficient.

(*b*) If the temperature at which the insulation resistance was measured differs from 60° F. (15.6° C.), the resistance shall be reduced to that at 60° F. (15.6° C.) by multiplying the measured value by the coefficient in Table III corresponding to the temperature at which the measurement was made.

Moisture Absorption Test.

32. (*a*) A 15-ft. sample with all the coverings removed shall be selected at random from the wire offered for inspection. The middle 10 ft. of the sample shall be immersed in distilled water for a period of 14 days with the 2½-ft. portion at each end kept above the water as leakage insulation. The three measurements specified in Section 8 shall be taken with the water at the same temperature. The water shall be maintained at room temperature but not less than 70° F. (21° C.).

TABLE III.—TEMPERATURE COEFFICIENTS.

Temperature		Temperature Coefficient	Temperature		Temperature Coefficient
Deg. Fahrenheit	Deg. Centigrade		Deg. Fahrenheit	Deg. Centigrade	
46	7.8	0.69	61	16.1	1.03
47	8.3	0.71	62	16.7	1.05
48	8.9	0.73	63	17.2	1.08
49	9.4	0.75	64	17.8	1.11
50	10.0	0.77	65	18.3	1.14
51	10.6	0.79	66	18.9	1.17
52	11.1	0.81	67	19.4	1.20
53	11.7	0.83	68	20.0	1.23
54	12.2	0.85	69	20.6	1.26
55	12.8	0.88	70	21.1	1.30
56	13.3	0.90	71	21.7	1.33
57	13.9	0.92	72	22.2	1.37
58	14.4	0.94	73	22.8	1.40
59	15.0	0.97	74	23.3	1.44
60	15.6	1.00	75	23.9	1.48

(*b*) The specific inductive capacity of the insulation shall be determined at commercial frequencies and shall be calculated as follows:

$$\text{Specific inductive capacity} = 13\,600\ C \log_{10} \frac{D}{d}$$

where C = the capacity in micro-farads of 10 ft. of sample;
D = the diameter over insulation; and
d = the diameter over conductor.

The moisture absorption test shall be made only when requested by the purchaser.

Rejection.

33. Each coil, reel or length which fails to comply with the electrical requirements of these specifications shall be rejected.

APPENDIX I

INTERPRETATION OF INSULATION THICKNESSES OF TABLE I

For series-street-lighting cable, use the following procedure:

(*a*) If the transformer is not equipped with protectors, use the open circuit secondary voltage of the transformer as rated voltage of the cable and select the proper wall thickness from Table I under the rated circuit voltage column headed "Grounded."

(*b*) If the transformer is equipped with protectors, use the closed or loaded secondary voltage of the transformer as the rated circuit voltage of the cable and select the proper wall thickness from Table I under the column headed "Grounded."

NOTE.—It is preferable, both in Paragraphs (*a*) and (*b*) above, to select a cable with a higher voltage rating than obtained using the above procedure, both as a measure of safety and to allow the substitution of a larger transformer without necessitating the replacement of the cable.

The thickness of insulation for the various systems shall be determined as follows:

(*a*) For three-phase systems with grounded or ungrounded neutral, use thickness values in accordance with the respective columns in Table I.

(*b*) For single or two-phase systems up to and including 5000 v., use thickness values in accordance with the grounded column of Table I.

(*c*) For single or two-phase systems operating at over 5000 v. with one side grounded, multiply the circuit voltage (phase-to-phase) by 1.73 and use the resulting voltage value to select the corresponding insulation thickness in the grounded column of Table I.

(*d*) For single or two-phase systems operating at over 5000 v. with the center grounded, multiply the circuit voltage (phase-to-phase) by 0.866 ($= \frac{1}{2}\sqrt{3}$) and use the resulting voltage value to select the corresponding insulation thickness in the grounded column of Table I.

(*e*) For non-leaded submarine cables, $\frac{1}{32}$ in. should be added to the specified respective walls of insulation in Table I for all sizes and voltages.

TENTATIVE SPECIFICATIONS AND TESTS
FOR
FRICTION TAPE FOR GENERAL USE FOR ELECTRICAL PURPOSES[1]

A.S.T.M. Designation: D 69 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1920; ADOPTED IN AMENDED FORM, 1924; REVISED, 1928; REISSUED AS TENTATIVE, 1932; REVISED, 1934.

Scope

1. These specifications cover friction tape commonly used for protecting and binding in place, insulation applied to joints of electrical wires and cables, and for other electrical and mechanical purposes. The tape consists of cotton sheeting that has been impregnated with an adhesive insulating compound and cut into rolls of narrow width.

MANUFACTURE

Cotton Sheeting

2. The cotton sheeting shall be evenly and firmly woven from good cotton and as free from unsightly defects, dirt, knots, lumps and irregularities of twist as is consistent with the best manufacturing practice. The threads shall run in as straight lines as possible, without waving, so as to reduce to a minimum the raveling of the cloth when cut into tape.

Frictioning Compound

3. The frictioning compound shall be a tacky adhesive insulating compound containing practically no free sulfur or other substances which would have a deteriorating effect on copper or other metals, or on the fabric.

Impregnation of Fabric

4. The fabric shall be thoroughly impregnated and evenly covered on both sides with the frictioning compound.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

These specifications are in effect a revision of, and replace the former Standard Specifications for Friction Tape for General Use for Electrical Purposes (A.S.T.M. Designation: D 69 – 28), which standard was accordingly discontinued in 1932.

Adhesiveness of Compound

5. The compound shall adhere firmly to the fabric, and shall not pull away from the fabric so as to leave bare spots when adjacent layers of tape are separated.

SAMPLING

Sampling

6. (*a*) The tape offered for inspection shall be divided into one or more lots of approximately equal numbers of rolls in accordance with the following table:

ROLLS OFFERED FOR INSPECTION	NUMBER OF LOTS
Up to 250	1
251 to 750	2
751 to 1500	3
1501 to 3000	4
3001 to 5000	5
Over 5000	5 plus 1 for each additional 1000 rolls.

The lots shall be marked for identification and one sample roll shall be taken at random from each lot for purpose of tests and marked to correspond with the lot from which it was selected. Each sample roll so chosen shall be tested in accordance with the specifications.

(*b*) At least 2 ft. of the outer layer of each roll selected for purpose of tests shall be removed and discarded before taking test specimens.

(*c*) The tape required for test specimens shall be unwound from the roll at a slow uniform rate without jerking.

CHEMICAL AND PHYSICAL PROPERTIES AND TESTS

Discoloration of Copper

7. The discoloration of copper test shall be made only when requested by the purchaser. Five superimposed layers of tape shall be wound on a clean, bright, smooth copper rod, approximately $\frac{1}{4}$ in. in diameter and 3 in. in length, and baked at 100 C. (212 F.) for 16 hr. in a sealed test tube. At the conclusion of the test the blue-black color, characteristic of copper sulfide, shall not appear on the rod at the edge of the tape.

Pinholes

8. The number of pinholes in three consecutive yards of tape selected at random from any portion of the sample roll shall not exceed six for $\frac{3}{4}$-in., eight for 1-in., twelve for $1\frac{1}{2}$-in., and sixteen for 2-in.

tape. Ruptures of the insulating film at the extreme edges of the tape, due to the slight tearing action of the cutting knife, shall not be considered pinholes.

Determination of Pinholes

9. The number of pinholes shall be determined while the tape specimen is held over a slot in the top of an illuminated box. The box shall be approximately 8 in. in width by 8 in. in height and 18 in. in length, inside dimensions. The slot shall be 2 in. in width by 12 in. in length. The box shall be painted white inside and illuminated by a 25-watt lamp. The slot shall be covered with clear glass set flush with the top of the box. Means shall be provided to limit the light to the width of the tape.

Tensile Strength

10. The tensile strength of the tape shall be not less than 40 lb. per inch of width. The initial distance between the jaws of the testing machine shall be 12 in. and the rate of separation of the jaws shall be 20 in. per minute.

Adhesion Test

11. (*a*) *Cold Adhesion Test.*—The adhesion between adjacent layers of the tape shall be determined as follows: A specimen 23 in. in length shall be removed from the sample roll, care being taken not to touch the surface to be tested with the hands or otherwise. One end of the specimen shall be inserted in the slot of the mandrel described below and 2 in. of the tape shall be wound on the mandrel. A weight of 10 lb. per inch of width shall then be attached to the end of the specimen and 19 in. of the tape shall be wound on the mandrel at a uniform rate of 12 in. per minute. The tape shall be allowed to remain 3 min. with the weight attached, after which a weight of 4 lb. per inch of width of tape shall be substituted for the weight of 10 lb. per inch of width, and the tape allowed to unwind. After 2 in. have unwound, the rate of unwinding shall be not greater than 15 in. in 1 min. The temperature of the room and the temperature of the tape shall be not less than 20 C. (68 F.) nor more than 22.2 C. (72 F.), except that tape meeting the adhesion test when tested at a higher room temperature shall not be rejected. The relative humidity at the temperature tested shall not exceed 80 per cent.

The mandrel used shall be $\frac{1}{4}$ in. in diameter with a slot approximately $\frac{1}{16}$ in. in width and long enough to accommodate the full width of tape, and shall be mounted in a level position in ball bearings of the Fafnir Bearing Co., Catalog No. 36, Serial No. 30, extra small, or equivalent ball bearings. The mandrel shall turn freely under a weight of $\frac{1}{4}$ oz., suspended from a cotton thread wound in a single layer on the center of the mandrel. See Fig. 1 for a suggested form of tape tester.

(*b*) *Oven Test.*—After a specimen of tape has been exposed to dry air at a temperature of not less than 99 C. (210.2 F.) nor more than 101 C. (213.8 F.) for 16 hr., and after a rest period at room temperature of not less than 1 nor more than 12 hr., the test specimen shall withstand the test prescribed in Paragraph (*a*), except that the weight applied to unwind the tape shall be 3 lb. per inch of width in place of 4 lb. per inch of width.

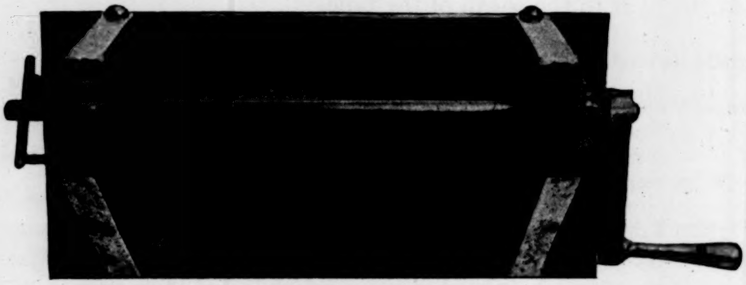


FIG. 1.—Tester for Adhesion Test of Friction Tape.

Tackiness

12. The tape shall show tackiness, that is, ability to stick to itself after light contact has been made, in the following combinations: (*1*) front to front, (*2*) back to back, and (*3*) back to front.

Tackiness Test

13. (*a*) Two 8-in. specimens shall be cut from each sample roll, care being taken not to touch the surface to be tested with the hands or otherwise. One specimen shall be placed lightly on a clean horizontal surface, then the second placed evenly upon the first. No weight or pressure other than the weight of the specimen shall be applied to the tapes. The two specimens shall be picked up from one end and then stripped slowly from each other starting at the same end. Tackiness in at least two of the combinations (*1*), (*2*) and (*3*) specified in Section 12 shall be such that the point of separation remains approximately in the same horizontal plane as the hands that pull the tape apart.

(*b*) Each combination specified in Section 12 shall be tested three times and if more than one test fails to comply with Paragraph (*a*), the tape is non-conforming to the combination in question. Otherwise, it conforms to the combination.

(*c*) New, clean specimens shall be taken for all tackiness tests. The temperature of the room and the temperature of the tape shall be not less than 20 C. (68 F.) nor more than 22.2 C. (72 F.), except that tape meeting the tackiness test when tested at a higher room temperature shall not be rejected. The relative humidity at the temperature tested shall not exceed 80 per cent.

Dielectric Strength

14. Each roll selected for purpose of tests shall be tested for dielectric strength. The breakdown voltage shall be not less than 1000 v.

Dielectric Strength Test

15. The dielectric strength shall be determined by placing a tape specimen, which shall be free from pinholes, between two flat electrodes, $\frac{1}{4}$ in. in width by 4 in. in length and having square edges and rounded ends. Under an electrode pressure of 1 lb. per sq. in., a 60-cycle alternating voltage of practically sine wave form shall be applied at a value not exceeding 100 v. and raised at a rate of 100 v. per second until puncture occurs. In order to prevent flashover, increased width may be secured by attaching to each side of the test specimen an added piece of tape, making a $\frac{1}{8}$-in. lap seam carefully rolled down.

Parallelism Test

16. Each sample roll shall be tested for parallelism of the warp threads with the longitudinal axis, as follows: A piece of tape 16 in. in length shall be cut from the sample roll and then torn lengthwise, assisting the tearing by first slitting one end for about $\frac{1}{2}$ in. with a knife. A 2-in. length shall then be cut from each end of one of the torn halves and the ends of the remaining 12-in. length folded together and compared. The difference between the compared widths shall not exceed $\frac{1}{8}$ in.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions

17. (*a*) The tape shall have a nominal thickness of 0.015 in. and shall be made in the following widths: $\frac{3}{4}$ in., 1 in., $1\frac{1}{2}$ in., and 2 in. Each roll shall contain not less than $82\frac{1}{2}$ ft. and not more than 85 ft. of tape.

Permissible Variations

(*b*) The thickness shall not vary from that specified by more than ±0.002 in., nor the width by more than $\pm\frac{1}{32}$ in.

Measurement of Thickness

18. The thickness shall be measured with a micrometer graduated to 0.001 in., having a circular foot 0.24 to 0.26 in. in diameter, and with a weight on the specimen of not less than 8 oz. nor more than 10 oz. Five measurements shall be made at random on a length of not less than 3 ft.

PACKING AND MARKING

Packing

19. Each roll shall be wrapped in paraffined paper or metal foil and, unless otherwise specified, enclosed in a suitable box. The wrapping shall be secure and shall thoroughly protect the contents.

Marking

20. Each box shall be marked with the name of the manufacturer or trade mark, together with the nominal width and length of the tape.

INSPECTION AND REJECTION

Time of Inspection

21. The tape shall be inspected and tested either at the place of manufacture before shipment or at the place of delivery within 4 weeks from date of delivery.

Storage and Guarantees

22. The tape shall be stored in the original boxes and preferably in a cool, dark location. Tape shall not be stored in close proximity to steam pipes, radiators or other sources of heat. The manufacturer shall guarantee to replace tape which at any time within 8 months after acceptance of the tape, if properly stored, will not meet the cold adhesion test specified in Section 11 (*a*), except that a weight of 3 lb. per inch of width of tape shall be substituted for the 4 lb. per inch, during unwinding.

Retests and Rejection

23. If any sample roll fails, two additional rolls shall be taken from the lot it represents and shall be tested. If either of these two additional sample rolls fails, the lot represented by the rolls shall be rejected.

TENTATIVE SPECIFICATIONS AND TESTS
FOR
RUBBER INSULATING TAPE[1]
A.S.T.M. Designation: D 119 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1921; REVISED, 1922, 1927, 1928, 1932, 1934.[2]

Scope

1. These specifications cover rubber insulating tape suitable for the insulation of joints in electrical wires and cables and for other insulating purposes.

MANUFACTURE

Compound

2. The tape shall consist of an unvulcanized or partially vulcanized rubber insulating compound. The compound shall be well, evenly and smoothly calendered, cut to the specified widths and tightly wound in rolls with a separator between layers. Preferably, the tape shall be dark gray in color.

Separator

3. The separator shall be parchment paper or glazed sheeting which shall be interposed between adjacent layers and cover the outside of the tape. The outside end of the roll shall be securely fastened. Upon originally unwinding the roll the separator shall show no undue tendency to stick to the rubber or to ravel.

CHEMICAL AND PHYSICAL PROPERTIES

Composition of Rubber Compound

4. The rubber compound shall contain not less than 30 per cent of the best quality crude Hevea rubber, nor more than 0.5 per cent of free sulfur to which may be added small percentages of antioxidant, waxy hydrocarbons and carbon black. The remainder shall consist of suitable inorganic mineral fillers. The compound shall contain no organic matter other than that specified in this section. The percentages shall be based on the weight of the original compound.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

Tensile Strength and Elongation

5. (*a*) The tensile strength of the tape shall be not less than 250 lb. per sq. in.

(*b*) The elongation of a 2-in. gage length determined simultaneously with the tensile strength test shall be not less than 300 per cent.

Dielectric Strength

6. The dielectric strength of the tape shall be not less than 350 v. per mil of thickness.

Fusion and Tackiness

7. The tape shall meet the fusion and tackiness tests specified in Sections 17 and 18.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions

8. The tape shall conform to the following nominal dimensions:

WIDTH, IN.	THICKNESS, IN.	LENGTH, FT.
$\frac{3}{4}$	0.030	30
$\frac{3}{4}$	0.030	15[a]
2	0.030	15

---

[a] Unless otherwise specified on the order, $\frac{3}{4}$-in. tape shall be supplied in rolls having a nominal length of 30 ft.

Permissible Variations in Dimensions

9. The thickness shall not vary from the nominal thickness more than ± 0.003 in. and the width not more than ± $\frac{1}{32}$ in. The length of the tape per roll shall be not less than the nominal length, nor the average length more than 5 per cent in excess of it.

PACKING AND MARKING

Packing

10. Each roll shall be enclosed in a suitable box.

Marking

11. Each box shall be marked with the name of the manufacturer or trade mark and the nominal width and length of the tape.

SAMPLING

Sampling

12. (*a*) All tape offered for inspection shall be divided into one or more lots of approximately equal numbers of rolls in accordance with the following table:

ROLLS OFFERED FOR INSPECTION	NUMBER OF LOTS
Up to 250	1
251 to 750	2
751 to 1500	3
1501 to 3000	4
3001 to 5000	5
Over 5000	5 plus 1 for each additional 1000 rolls

The lots shall be marked for identification and one sample roll shall be taken at random for purpose of tests from each lot and marked to correspond with the lot from which it was selected. Each sample roll so chosen shall be tested according to the specifications.

(*b*) At least 2 ft. of tape from each roll shall be removed and discarded before taking test specimens.

METHODS OF TEST

Chemical Analysis

13. The chemical analysis of the rubber compound shall be made in accordance with the short procedure described in Sections 1 to 14 of the Standard Methods of Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297) of the American Society for Testing Materials.[1]

Room Temperature

14. The temperature of the room in which the tensile strength, elongation and fusion tests are made shall be between 68 and 82 F. (20 and 28 C.).

Tensile Strength and Elongation Tests

15. The tests for tensile strength and elongation shall be performed in accordance with the Standard Methods of Physical Testing of Rubber Products (A.S.T.M. Designation: D 15) of the American Society for Testing Materials,[2] with the following exceptions:

(*a*) The room temperature shall be as specified in Section 14.

(*b*) The test specimens shall be cut from a laminated sample, two ply thick, carefully rolled together to avoid entrapped air. The thickness of the composite specimen shall be used in calculating the tensile strength.

(*c*) The dumbbell-shaped $\frac{1}{2}$ by 2-in. test specimen shall be used and shall be cut with the A.S.T.M. standard die as shown in Figs. 1 and 2 (*a*) of Standard Methods D 15, except that the ends of the specimen cut from $\frac{3}{4}$-in. tape need not be full width. In placing the parallel gage marks on the test specimen care shall be taken not to cut the stock.

---

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1130.

[2] *Ibid.*, p. 1154.

(*d*) Three specimens, free from visible defects, from each sample roll shall be tested. The average of the three tests shall be reported.

Dielectric Strength Test

16. The dielectric strength shall be determined by placing a specimen approximately 6 in. in length between two flat electrodes $\frac{1}{4}$ in. in width by 4 in. in length having square edges and rounded ends. Under an electrode pressure of 1 lb. per sq. in., a 60-cycle alternating current voltage of practically sine wave form shall be applied at a value less than 1000 v. and raised at the rate of 1000 v. per sec. until puncture occurs. In order to prevent flashover, increased width may be secured by attaching to each side of the test specimen an added piece of tape, making a $\frac{1}{8}$-in. lap seam carefully rolled down.

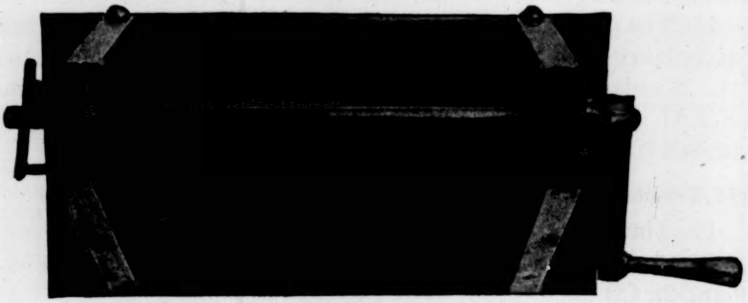


FIG. 1.—Tester for Fusion Test.

Fusion Test

17. (*a*) A specimen 7 in. in length shall be taken from the roll, care being taken not to touch the surface to be tested with the hands or otherwise and 2 in. of the specimen wound on the mandrel, and then a weight of 4 lb. per inch of width of tape shall be attached to the end of the specimen. Should this weight not be sufficient to elongate the tape 200 per cent, additional downward force shall be applied by hand until the desired elongation has been produced. The tape shall then be wound on the mandrel at a uniform rate of 12 in. per min. and allowed to stand for 3 min. with the weight attached. It shall then be allowed to unwind slowly until the fused turns are reached. The mandrel shall revolve not more than two and one-half turns before the fused turns are reached. The tape shall sustain the weight for 2 min. without further unwinding or shall break at the point of unwinding.

(*b*) The mandrel used shall be $\frac{1}{4}$ in. in diameter and shall be mounted in a level position in ball bearings of the Fafnir Bearing Co. Catalog No. 36, Serial No. 30, extra small or equivalent ball bearings. The mandrel shall turn freely under a weight of $\frac{1}{4}$ oz., suspended from a cotton thread wound in a single layer on the center of the mandrel. See Fig. 1 for a suggested form of tape tester.

Tackiness Test

18. A specimen 7 in. in length shall be taken and wound on the mandrel in the same manner as described in Section 17. Instead of leaving the weight suspended for 3 min. it shall be immediately removed. The tape shall show no tendency to unwind from the mandrel.

Measurement of Thickness

19. The thickness shall be measured with a micrometer graduated to 0.001 in., having a circular foot of 0.24 to 0.26 in. in diameter, and with a weight on the specimen of 9 oz. ± 0.1 oz. Five measurements shall be made at random on a length of not less than 3 ft.

INSPECTION AND REJECTION

Inspection

20. The tape shall be tested and inspected either at the place of manufacture before shipment or at the place of delivery within 4 weeks from date of delivery.

Storage and Guarantees

21. The tape shall be stored in the original boxes and preferably in a cool, dark location. Tape shall not be stored in close proximity to steam pipes, radiators or other sources of heat. Provided the tape has been properly stored, the manufacturer shall guarantee to replace, without charge, any tape which at any time within 8 months after receipt of a shipment will not meet the fusion test specified in Section 17 or to which the separator becomes unduly attached.

Retests and Rejections

22. (*a*) If the tape fails in any one test of those prescribed in these specifications, two additional rolls shall be selected and submitted to that test. If either of these two additional rolls fails, the lot represented by the test rolls shall be rejected.

(*b*) The manufacturer shall replace the rejected tape and shall pay freight charges for the return of such material.

TENTATIVE METHODS OF TEST

FOR

ABRASION RESISTANCE OF RUBBER COMPOUNDS[1]

A.S.T.M. Designation: D 394 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934; REVISED, 1934.[2]

Scope

1. This method is designed to measure the abrasion resistance of soft vulcanized rubber compounds, such as gum stocks, boot and shoe stocks, tread stocks, etc. No relation between this test and service performance is given or implied. The significance to be attached to the results can only be determined by each laboratory for its particular problem. It shall not be used for purchase specifications because of the difficulty of reproducing comparison standard compounds in separate laboratories. The value of having the test in standardized form for inter-comparisons and for the interpretation of results is, however, unquestioned.

Type of Materials Tested

2. Any vulcanized rubber compound, whether prepared experimentally in the laboratory, taken from process during manufacture, or cut from a finished article of commerce (providing a section of sufficient size is available), may be tested. It is assumed that the bulk of the testing will be on compounds especially designed to withstand abrasion, and that the test will be carried out with a comparison standard of the same general characteristics.

Comparison Standards

3. In order to cover the large variety of compounds that can be tested under this method, the following three standard compounds are recommended as comparison standards. The sample shall be compared with that comparison standard having physical properties (stress-strain values and hardness) most nearly matching the sample compound.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

[2] Revision accepted by Committee E-10 on Standards, August 22, 1934.

	COMPARISON STANDARDS		
	A	*B*	*C*
	PARTS BY WEIGHT		
First latex pale crepe	50	......	......
No. 1 smoked sheet	50	100	100
Zinc oxide	5	20	5
Channel carbon black	..	30	45
Stearic acid (c. p.)	1	2	4
Medium pine tar	..	......	4
Mercapto-benzo-thiazole	1	......	1
Diortho-tolyl-guanidine	..	1.25	......
Phenyl-beta-napthylamine	1	1	1
Sulfur	3	3.5	3
Cure	60 min. at 259 F. (126 C.) (20 lb. steam)	60 min. at 287 F. (142 C.) (40 lb. steam)	70 min. at 259 F. (126 C.) (20 lb. steam)

NOTE.—It is recognized that the compounding materials shown above may vary and should be completely defined. The attention of Committee D-11 on Rubber Products is directed toward this problem in the hope of arriving at a satisfactory solution.

Preparation of Comparison Standard[1]

4. Having determined which of the three comparison standards is to be used, the following procedure shall be followed:

(*a*) *Weighing Tolerances.*—Weighing of all ingredients shall be accurate to within 0.25 per cent of the weight specified. The final weight of the mixed batch and the sum of the weights of each ingredient shall not differ by an amount exceeding 0.6 per cent for a compounded stock or 0.3 per cent for pure gum or master-batched stocks.

(*b*) *Mill Data.*—The rolls of the laboratory mill shall be 6 in. in outside diameter by 12 in. in length with 10½ in. between guides. The speed of the slow roll shall be 24 r.p.m. and the gear ratio 1.4 to 1.

(*c*) *Mill Temperature.*—The temperature of the water entering the rolls shall be maintained at 158 F. (70 C.) and the initial temperature of the rolls shall be 158 F. (70 C.). With sufficient water passing through the rolls and a uniform initial temperature, it is certain the mixing process can be made quite uniform.

(*d*) *Mill Opening.*—It is essential that the relation between batch volume and mill opening shall be regulated to develop an active bank. Since it is neither practical nor economical to standardize the size of the batch, it is recommended that mill openings be adjusted to the volume of batches as shown in the following table:

---

[1] This procedure has been adapted from the "Tentative Standard Laboratory Procedure for the Preparation and Physical Testing of Rubber Samples" prepared by the Physical Testing Committee, Rubber Division, Am. Chemical Soc., *The Rubber Age* (New York), January 28, 1930.

VOLUME OF BATCH, CC.	DISTANCE BETWEEN ROLLS, IN.
1200	0.170
1100	0.160
1000	0.145
900	0.130
800	0.120
700	0.110
600	0.100
500	0.085
400	0.070
300	0.055

(*e*) *Mixing Procedure.*—During breakdown, the mill opening shall be 0.055 in. until the rubber runs smooth on the roll, and then the opening shall be made to correspond to the volume of the batch in the foregoing table. The order of adding ingredients to the broken down rubber shall be as follows:

Accelerators and antioxidants
Black
Fillers
Softeners
Sulfur

The ingredients shall be incorporated as rapidly as possible and when all are in the rubber the batch shall be cut six times two-thirds of the distance across the roll, held until the bank just disappears alternating from one side to the other. Then the batch shall be cut across and rolled six times inserting the roll endwise five times and the last time it shall be inserted lengthwise. As soon as the bank is well balanced, the mill opening shall be set to give a sheet slightly greater in thickness than the test specimen after cooling and the batch shall then be cut from the rolls.

(*f*) *Storage of Mixed Batch.*—The batch shall be laid upon a suitable surface (zinc, holland, talced zinc makes no difference) until cool, after which it shall be stored 18 to 24 hr. on galvanized wire screen (6 mesh is convenient) in subdued light with free circulation of air having a relative humidity of 45 per cent at 82 F. (27.6 C.). Variation of 0 to 100 per cent relative humidity may cause a difference of 25 per cent in physical properties.

(*g*) *Preparation for Curing.*—The uncured stock shall be cut with a die having dimensions slightly less than those of the mold. Care shall be taken to have the stock so placed in the mold, that the direction of the grain will be parallel to the direction of abrasion when the vulcanized specimen is mounted in the abrader.

(*h*) *Mold Dimensions.*—Mold dimensions shall be governed by the test specimen needed for the test used.

(*i*) *Cleanliness of Molds.*—No preparation of any kind shall be used on molds to prevent sticking. The molds shall be kept clean, and shall be cleaned as soon as the cured stock tends to stick. Three cleaning materials are suggested: (*1*) ground emery and water, (*2*) buffer cloth, (*3*) whiting paste.

(*j*) *Maintenance of Curing Temperature.*—The specified curing temperature shall be interpreted as the inside temperature of the mold as determined by a thermocouple or a mercury thermometer in a mercury well in the mold. A similar steel block with a mercury well may be substituted for the mold as described in a previous report.[1] To avoid cool spots in platens due to condensation, presses with bored steel platens are recommended. If chamber type platens are used, good drainage should be insured by placing the steam outlet slightly below the bottom of the steam chamber.

(*k*) *Mold Temperature and Protection.*—The mold shall be brought to temperature in a closed press for a period of not less than 20 min. before inserting the uncured stocks. While curing, the mold shall be protected from drafts, by the use of some sort of shields or wooden ells. Protection often causes a rise of 1.8 F. (1 C.) in mold temperature.

(*l*) *Timing of Cure.*—The time of cure shall start at the time the ram pressure reaches its maximum and end at the release of the ram pressure.

(*m*) *Cooling Cured Slabs.*—The slabs shall be removed from the mold immediately after conclusion of the cure and plunged into water for at least 10 min. to cool. The water shall be changed frequently to prevent contamination and heating. When removed from the water the slabs shall be wiped dry and placed upon liner or screen for storage in subdued light.

(*n*) *Conditioning of Specimens.*—The test specimens shall be conditioned for 24 hr. in air having a relative humidity of 45 per cent at 82 F. (27.6 C.) before testing at the same temperature.

(*o*) *Preparation for Test.*—That face of the test specimen which is to be abraded shall be lightly buffed before test, except in those cases where otherwise specified.

(*p*) *Maintenance of Standards.*—It is recommended that sufficient standard compound be prepared at one time to last approximately one month. Subsequent batches of standard shall be tested for stress-strain properties and hardness and shall not vary more than 10 per cent from the original standard adopted. Its abrasion resistance shall be within 5 per cent of the batch of comparison standard being used at that time.

---

[1] See Report of Physical Testing Committee, Rubber Division, Am. Chemical Soc., ***Industrial and Engineering Chemistry***, Vol. 17, No. 5, p. 535, May, 1925.

Preparation of the Sample

5. (*a*) If a laboratory comparison is being made, the sample shall be prepared by the same procedure as described in Section 4 for the preparation of the comparison standard.

(*b*) If stock is taken from production, the sample shall be prepared as described in Section 4 (*f*) to (*p*), inclusive, for the preparation of the comparison standard.

(*c*) If an article of commerce is being tested, a piece somewhat larger than the test specimen required shall be cut from the sample and subsequently trimmed and buffed to size.

Method A. National Bureau of Standards Abrader[1]

Test Specimen

6. The test specimens shall be 1 in. square by $\frac{1}{4}$ in. in thickness.

Apparatus

7. The essential features of the apparatus, illustrated in Fig. 1, are as follows: The rubber-coated metal drum, *a*, is 6 in. in diameter and is rotated at 40 r.p.m. by an electric motor with a reducing mechanism, the revolutions of the drum being indicated by a counter attached to one end of the shaft. The three arms, *b*, are each pivoted at one end, and each having a weight suspended at the other end, such that a downward force of 5 lb. is exerted directly on the test specimen on the underside of the arm, *h*. The three dial gages, *c*, graduated in thousandths of an inch, fastened to a bridge so that each contacts with the corresponding arm, *b*, at a point directly over the test specimen. This bridge is hinged at one end to allow the arms to be swung back for the placing of test specimens on them. The compressed air line, *d*, is provided for keeping the abrasive surface clean. Arm stops, *e*, and an abrasive, *f*, consisting of No. $2\frac{1}{2}$ garnet paper or cloth 6 in. in width, held on the rubber-covered drum by four rubber bands. The ends of the abrasive sheet are cut at an angle of about 80 deg. and when in place have a clearance of about $\frac{1}{16}$ in. Test specimens, *g*, 1 in. square and approximately $\frac{1}{4}$ in. in thickness are cemented to small fiber disks which in turn are fastened to the weighted arms.

---

[1] P. A. Sigler and W. L. Holt, "A Simple Abrasion Test Machine for Rubber," *India Rubber World*, Vol. 82, No. 5, p. 63, August, 1930.

Procedure

8. (*a*) In making a test, the specimens shall first be allowed to wear until the surface conforms to the shape of the drum. The machine shall then be stopped, the gage bridge locked in place, and all gages and the counter set at zero. The machine shall then be run until about 0.1 in. has been abraded from the standards, and the machine again stopped, and the counter and gage readings recorded. The readings shall always be taken with the drum in the same position. For routine work, these readings give the abrasion resistance in terms of "revolution per 0.1 in. wear."

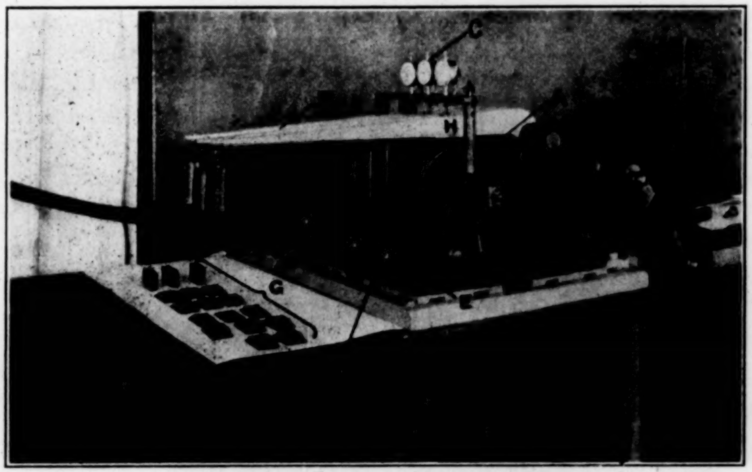


FIG. 1.—National Bureau of Standards Abrader.

(*b*) For purposes of conforming to this method, the weight of the test specimen before and after abrading may be measured and the volume loss calculated.

(*c*) From the loss in weight, the volume loss and abrasion resistance shall be calculated in accordance with Section 24.

Method B. E. I. du Pont de Nemours and Co. Abrader[1]

Test Specimen

9. The test specimens shall be 2 cm. square by 1 cm. in thickness.

Apparatus

10. The essential features of the apparatus illustrated in Fig. 2 are as follows: A disk which carries an abrasive surface is mounted

---

[1] Ira Williams, "Measurement of Abrasion Resistance of Rubber," *Industrial and Engineering Chemistry*, Vol. 19, No. 6, p. 674, June, 1927.

on a hollow shaft and rotates counter-clockwise in a vertical plane at a speed of 37 r.p.m. Two test specimens are mounted on the inside of a bar, one placed at each end and at a distance of 4.5 in. apart. This bar is attached permanently to a rod (axis) which extends through the hollow shaft carrying the abrasion disk. A weight attached to the end of this rod by means of a cable and acting over a pulley holds the test specimens against the abrasive. A lever arm is attached to the end of the bar which holds the test specimens. The other end of this lever arm carries a bucket, the weight of which is adjusted with shot, just enough to prevent rotation. A vernier spring balance is attached to the lever arm for final adjustment of the load. The abrasive generally used is No. 0 emery paper. The abrasive surface is cleaned by means of air jets.

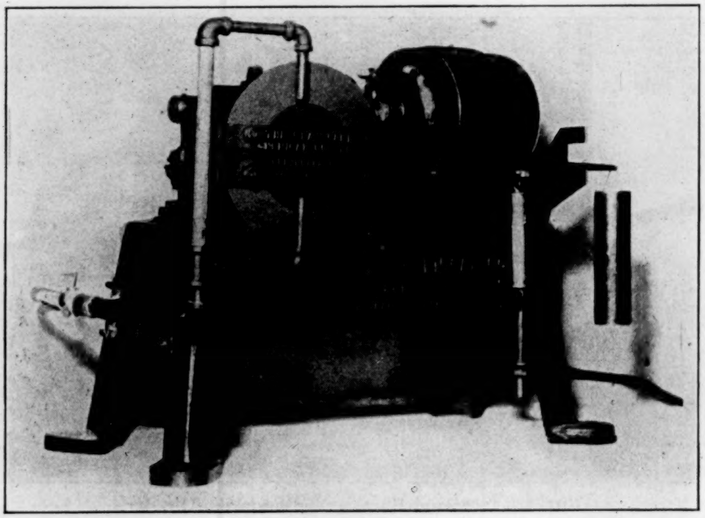


FIG. 2.—E. I. du Pont de Nemours and Co. Abrader.

Procedure

11. (*a*) Two test specimens shall be inserted in the clamps of the balance lever and the clamps then tightened uniformly, care being taken to avoid distorting the surface to be abraded. The balance lever shall be placed in position with its axis rod extending through the hollow shaft which supports the abrasive disk.

The same procedure shall be followed inserting two test specimens of the comparison standard in the clamps. The 3.62-kg. weight shall be connected to the end of the axis rod, leveling the cable over the grooved pulley, thus holding the test specimens evenly and firmly against the abrasive disk. The balance weight (bucket) shall be attached to the end of the lever arm and the spring balance connected to the lever arm (for most tests the total weight of the bucket and shot will be 500 g.).

(*b*) The surface of the abrasive disk shall first be cleaned by applying 20-lb. air pressure to them through the jets. The air shall be filtered to remove oil, water and dirt. Any evidence of these appearing on the abrasive disk shall be cause for repeating the test. The machine shall be run until the test specimens are seated evenly, the specimens then removed and weighed. The test specimens shall then be replaced in exactly the same position as before and run for 20 min., adjusting the load applied by means of the spring balance to offset rotation of the balance lever. The lever arm will fluctuate slightly between the stops provided on the machine, but should not touch the stops. At the completion of the test, the specimens shall be removed and weighed.

(*c*) From the loss in weight, the volume loss and abrasion resistance shall be calculated in accordance with Section 24.

Method C. The B. F. Goodrich Co. Abrader[1]

Test Specimen

12. The test specimens shall be rings 1.5 in. in outside diameter by 1 in. in inside diameter and at least $\frac{3}{32}$ in. in thickness.

Apparatus

13. The essential features of the apparatus, illustrated in Fig. 3, are as follows: A steel mandrel 1 in. in diameter and 3 in. in length, over-all, on which the ring test specimens are mounted, and a cylindrical can 3 in. in diameter and 9 in. in depth filled with No. 6 carborundum. In addition to the ring specimens, the mandrel carries hardened steel spacer rings 1 in. in inside diameter by $1\frac{5}{32}$ in. in outside diameter by $\frac{3}{16}$ in. in thickness, which are knurled on the faces adjacent to the specimens. These serve to keep the specimens separated and to clamp them firmly when assembly is completed by tightening a nut on the end of the mandrel. The mandrel is fastened to a vertical shaft in such a way that the sample rings are revolved at fixed depths in the can filled with carborundum. The mandrel is

---

[1] W. W. Evans, "An Apparatus and Method for Determination of Resistance to Abrasion of Rubber Products," *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part II, p. 517 (1923).

driven by a reversible motor at a speed of 120 r.p.m. The can has an 8-mesh screen on the bottom to permit broken grains and rubber dust to escape. The abrasive mixture is always screened after use, one part of new abrasive being added to four parts of old before screening. This proportion maintains a uniform supply of abrasive.

Procedure

14. Test specimens of both the sample and the comparison standard shall be weighed and placed on the mandrel, alternating the sample and the comparison standard. All specimens shall be kept separated by hardened steel spacers. The mandrel shall be mounted on the shaft, the can placed around it and the carborundum filled in around the rings. The motor shall then be started, the time noted, and the specimens attached to the mandrel allowed to revolve in the carborundum. When the test is half finished, the mandrel shall be turned upside down and the motor reversed in order to

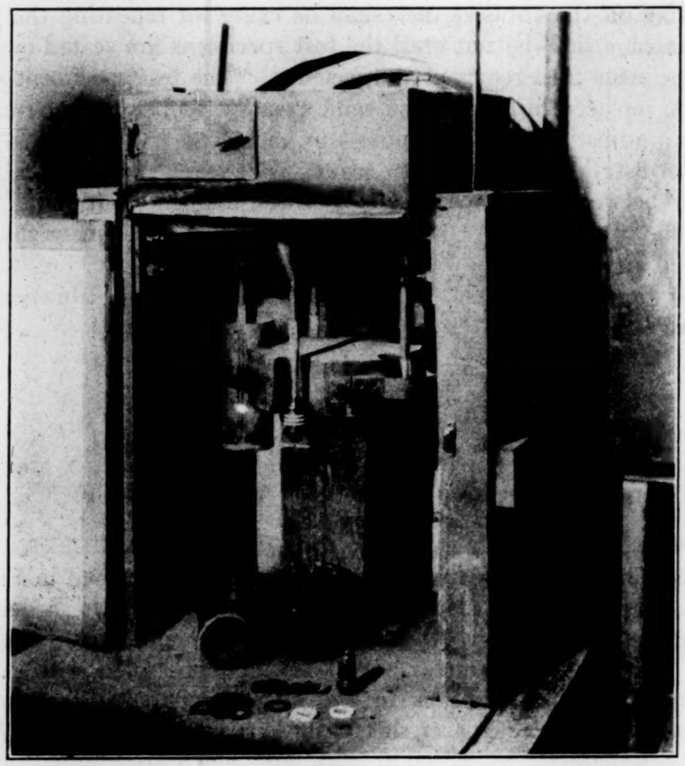


FIG. 3.—The B. F. Goodrich Co. Abrader.

equalize the abrasion on the test specimens. The duration of the test depends on the rate of wear of the material being tested. In general, the test shall be continued until there is at least 100 mg. loss in weight on each of the specimens. At conclusion of the test, the specimens shall be weighed and the loss in weight obtained by difference.

NOTE.—*Example:* A compound of quality similar to that in rubber heels may require a wearing period of approximately 2 hr., while a high grade pure rubber compound such as inner tube stock may require 6 hr. for satisfactory results.

(*d*) From the loss in weight, the volume loss and abrasion resistance shall be calculated in accordance with Section 24.

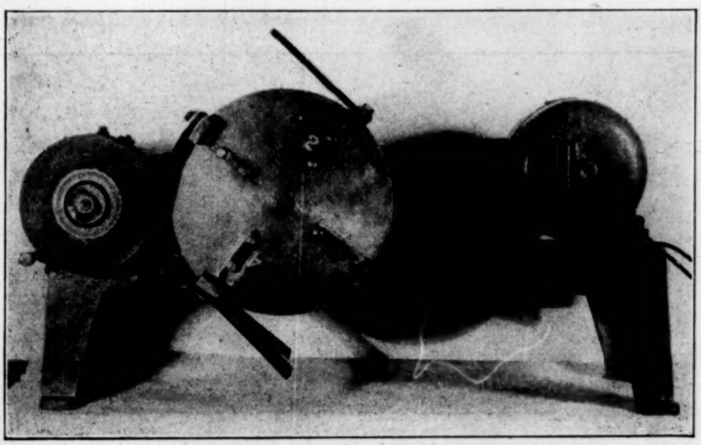


FIG. 4.—Kelly-Springfield Abrader.

Method D. Kelly-Springfield Abrader[1]

Test Specimen

15. The test specimens shall be mold-cured slabs $2\frac{1}{2}$ by $5\frac{3}{16}$ in. by $\frac{1}{4}$ in. in thickness with a very slight offset under the specified thickness at one end provided for mounting the specimen.

Apparatus

16. The essential features of the apparatus, illustrated in Fig. 4, are as follows: An abrasive wheel (Note) $1\frac{1}{2}$ in. in width and 6 in. in diameter which travels against the face of the specimen at a rate of 2386 ft. per minute. For mounting the specimens tangentially to the 10-in. wheel which revolves at 70 r.p.m., plates of spring steel $\frac{1}{2}$ in. shorter than the specimen shall be used.

NOTE.—Abrasive Wheel No. 1960-J made by the Norton Co., Worcester, Mass., or its equivalent, is satisfactory.

---

[1] A. P. Hardman, W. L. Mackinnon and S. M. Jones, "The Kelly Abrasion Machine," *The Rubber Age*, Vol. 28, No. 9, p. 463, February 10, 1931.

Procedure

17. (*a*) The specimens shall be trimmed and then weighed to the nearest centigram before mounting on the spring plates. Three different compounds and the comparison standard shall be tested on four different runs of the machine. The position of each specimen shall be changed after each run and the results averaged. All positions of the mounted specimen must be kept filled during each test, if only with blanks, to protect the spring plates from the abrasive wheel. Each test shall be run for 675 revolutions of the test specimen, and the specimen shall be again weighed after cleaning thoroughly.

(*b*) From the loss in weight, the volume loss and abrasion resistance shall be calculated in accordance with Section 24.

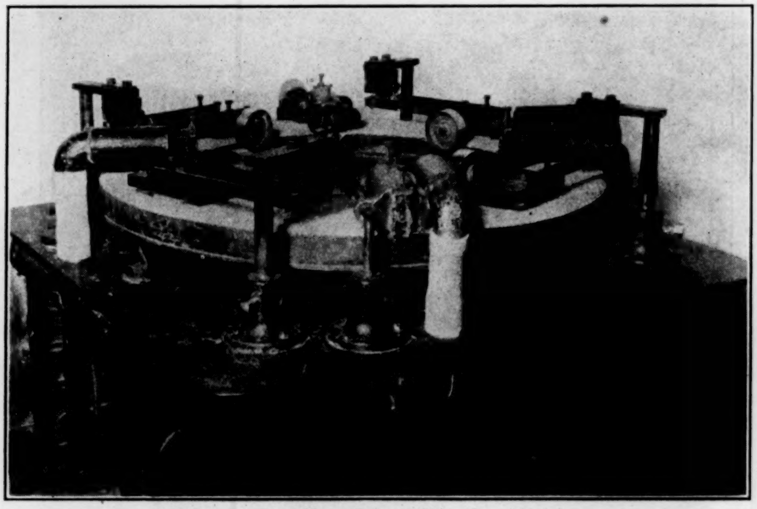


FIG. 5.—The New Jersey Zinc Co. Abrader.

Method E. The New Jersey Zinc Co. Abrader[1]

Test Specimen

18. The test specimens shall be blocks of rubber compound 2 by 2 in. by 0.25 in. in thickness. For convenience, a mold 2 by 7 in. may be used, providing three test specimens.

Apparatus

19. The essential features of this testing apparatus, illustrated in Fig. 5, are as follows: The horizontal abrasion track is 30 in. in

---

[1] H. A. Depew, "An Explanation of Some of the Difficulties in Abrasion Testing of Rubber," *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part II, p. 871 (1928).

outside diameter and 24 in. in inside diameter, the abrasive surface being feldspar embedded in concrete. The track is revolved at a speed of 30 r.p.m. and the dust is removed by brushes and suction. The machine is provided with four arms which bear on the abrasive track and six lifts raise and lower the 2 by 2 by 0.25-in. specimens to give cutting and tearing action.

Procedure

20. (*a*) After dieing out the test specimen to the 2 by 2 in. by 0.25-in. size, it shall be buffed lightly on a large surface. A holder, made up of hard rubber faced with a soft rubber surface on one side shall be used, to which the test specimen shall be cemented. The mounted samples shall be placed in a clamp under pressure for approximately 12 hr. before testing.

(*b*) Four test specimens shall be placed into the slots of the four arms of the abrasion machine. Three specimens of unknown value shall be tested along with a specified comparison standard. The tracks shall be revolved at 30 r.p.m., the usual test being 1000 revolutions of the track. If a specimen should wear through before the 1000 revolutions are completed, a warning is provided by the soft blue rubber facing on the hard rubber holder. In such a case, the calculations shall be based on the actual number of revolutions of the track to failure.

(*c*) The track shall be kept free from the abraded rubber dust by means of air suction and revolving brushes at each of the four arms.

(*d*) The samples shall be weighed before and after abrasion. From the loss in weight, the volume loss and abrasion resistance shall be calculated in accordance with Section 24.

Method F. United States Rubber Co. Abrader[1]

Test Specimen

21. The test specimens shall be slabs 2 by 3 by $\frac{3}{8}$ in. or 2 by 5 by $\frac{3}{8}$ in. to fit the standard machine.

Apparatus

22. The essential features of the apparatus, illustrated in Fig. 6, are as follows: A rotating wheel 3 in. in diameter with the outer rim 1 in. in width and covered with an abrasive cloth (metallic cloth, 60 grit). A specimen carrier moves the test specimen held in a suitable grip against this wheel, the wheel rotating against the direction of the movement of the table. The rotation of the wheel is reversed at the time the movement of the specimen table is reversed. Mechanical

---

[1] Described in catalogue of Henry L. Scott Co.

means are provided to raise the wheel from the work as it passes from specimen to specimen. An exhaust blower is provided to remove all dust from the wheel and specimens, and a small revolving brush to clean the wheel thoroughly as it is raised between the grinding of each specimen. This will insure against the carrying of particles from one specimen to the next. A balance arm is provided for the purpose of regulating the pressure of the wheel on the specimens.

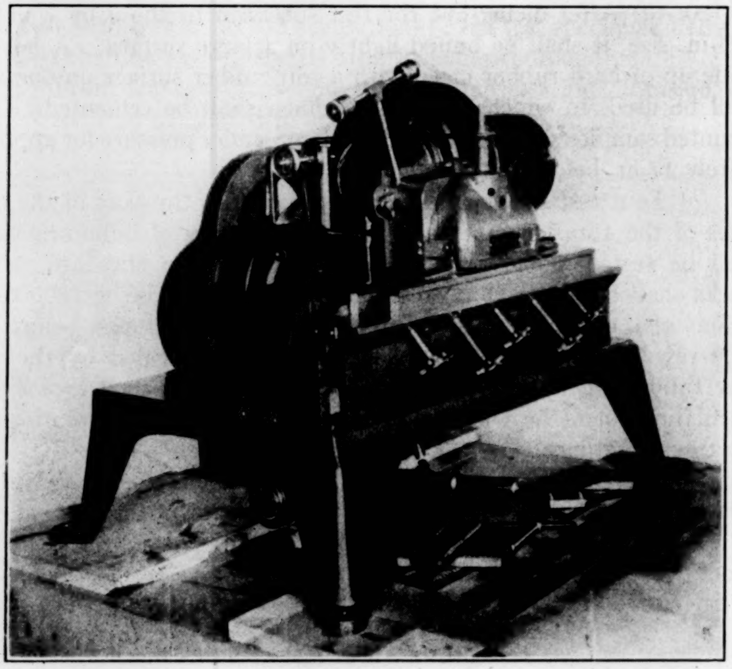


FIG. 6.—United States Rubber Co. Abrader.

The machine is equipped with a counter which registers the number of cycles or applications of the abrasive wheel to each specimen.

Procedure

23. (*a*) After the specimens to be tested have been weighed, they shall be placed in the machine and firmly fastened in place, care being taken that the faces to be abraded are all in the same plane and exactly flush with the restraining edges of the traveling table. A fresh piece of abrasive cloth shall be used for each test.

(*b*) The machine should be at the end of a cycle so that when started, each specimen will receive the same number of applications of the abrasive wheel provided that at the conclusion of the test the machine is again stopped at the end of a cycle. The machine is geared to make nine cycles per minute and the length of the test to be made will necessarily depend upon the type of stock being tested. The test shall be run long enough to remove sufficient quantity of the specimen by abrasion to reduce the percentage of error to a minimum. A general rule which should apply requires that the test run until the specimen has been abraded to such a depth that there is still 0.15 in. (0.039 cm.) of material at the point of the deepest cut. The test shall be stopped at a convenient time when abrasion has proceeded to practically this point, at an even number of cycles to facilitate the calculation of results to a common basis for comparison. The test specimens shall then be removed and weighed after brushing them off to remove any loose particles which might remain adhering to the specimens.

(*c*) From the loss in weight, the volume loss and abrasion resistance shall be calculated in accordance with Section 24.

Calculation of Results

24. (*a*) In each of the six alternative methods of test described in Sections 6 to 23 the loss in weight of the test specimen shall be accurately measured to within ± 1 mg., unless otherwise specified.

(*b*) The specific gravity of the stock shall be determined to the second decimal place. The volume loss shall be calculated by dividing the loss in weight by the specific gravity.

(*c*) The abrasion resistance shall be calculated by dividing the volume loss of the standard by the volume loss of the sample and multiplying by 100.

(*d*) The results shall be expressed as a percentage of the comparison standard specified.

Note.—*Example:* 110 per cent of A.S.T.M. Comparison Standard *A*.

TENTATIVE METHOD OF TEST
FOR
COMPRESSION SET OF VULCANIZED RUBBER[1]

A.S.T.M. Designation: D 395 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.

Scope

1. This method is designed for testing vulcanized rubber parts which are to be assembled in such a manner that the rubber will be subjected to compressive stresses or shear. It is applicable particularly to the rubber used in machinery mountings and vibration dampers.

Definition

2. For the purposes of this test, compression set of rubber shall be considered as the residual decrease in thickness, expressed as the percentage of the original thickness, of a test specimen measured 30 min. after the release from a specified constant compressive load to which the test specimen had been subjected for a definite time at a specified temperature in a suitable loading device.

APPARATUS

Compression Device

3. The compression device shall consist of two parallel platens between which the test specimen is compressed and a calibrated loading spring, all mounted in a suitable housing having a screw mechanism for compressing the spring to apply the load and equipped with a scale graduated in hundredths of an inch for measuring the deflection of the spring. The device shall be portable, self-contained and capable of applying the desired load gradually and uniformly over the entire top and bottom surfaces of the test specimen for the duration of the test. A suitable compression device is shown in Fig. 1.

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-11 on Rubber Products.

Spring

4. The loading spring shall be made of properly heat-treated spring steel with ends ground square and perpendicular to the longitudinal axis of the spring so as to help in keeping the platens parallel throughout the test. The spring shall conform to the following requirements:

(*a*) The spring shall be calibrated at room temperature (24 C. ± 5 C.) by applying successive increments of load of 50 lb. ±0.5 lb. and measuring the corresponding deflections in hundredths of an inch. The curve obtained by plotting the loads against the corresponding deflections shall have a slope of 4.0 ± 0.2 at 400-lb. load. The slope is obtained by dividing the difference between two loads expressed in pounds by the difference between the corresponding deflections expressed in hundredths of an inch.

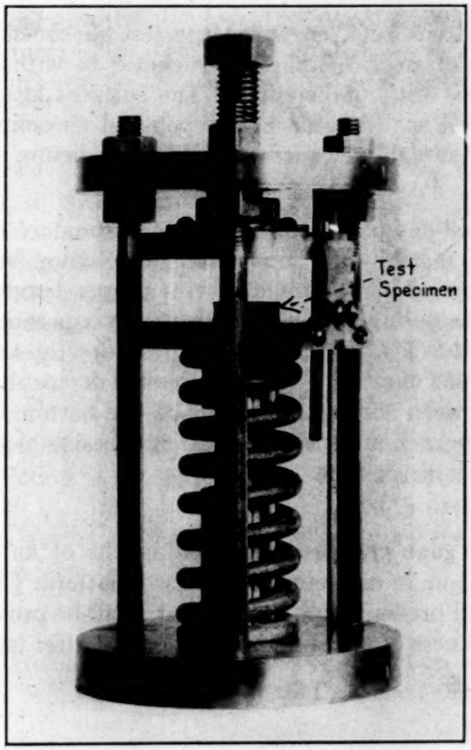


FIG. 1.—Device for Compression Set Test.

NOTE.—*Example:* A spring which deflects 1.00 in. at 400 lb. and 0.75 in. at 300 lb. gives a slope of 4.0.

(*b*) The original dimensions of the spring shall not change due to fatigue by more than 0.01 in. after it has been mounted in the compression device, compressed under a 400-lb. load and heated in the oven for one week at 70 C. (158 F.). In ordinary use a weekly check of the dimensions shall show no greater change than this over a period of one year.

(*c*) The minimum load required to close the spring solid shall be 530 lb.

Platens

5. The platens between which the test specimen is compressed shall be made of steel of sufficient thickness to withstand the compressive stresses without bending. The surfaces against which the specimen is held shall have a highly polished chromium plate finish and shall be thoroughly cleaned and wiped dry before each test.

Oven

6. Any well-designed, uniformly heated standard dry-air oven of sufficient size to hold the compression device may be used for this test. The oven shall be provided with proper temperature control to maintain the specified temperature within a permissible variation of ±1 C. (±1.8 F.). Satisfactory circulation of the air shall be secured by means of a fan. The compression device shall be centrally located in the oven and supported above the bottom of the oven by means of a wire rack mounted on wood or asbestos block so that they are heated by indirect heat.

Gages

7. A dial gage graduated in thousandths of an inch having a spherical foot $\frac{1}{4}$ in. in diameter and a raised platform $\frac{3}{8}$ in. in diameter, exerting a total pressure of 3 oz. ±0.1 oz. shall be provided for measuring the thickness of the specimen before and after loading.

TEST SPECIMENS

Test Specimens

8. (*a*) *Standard Test Specimen.*—The standard test specimen shall be a rectangular block 1 in. in length by 1 in. in width by $\frac{1}{2}$ in. in thickness cut from the vulcanized rubber part by means of a sharp knife and buffed carefully to the exact size within a permissible variation on each dimension of ±0.005 in. The buffing shall be lightly done to avoid overheating and care must be taken to keep the faces parallel.

(*b*) *Special Test Specimen.*—In routine production testing it is sometimes more convenient to cut test specimens of a different size and shape than that specified as standard. When any other size of specimen is used the test results shall not be compared with those secured using the standard test specimen. When using specimens of special sizes or shapes the results may be compared only with those from similar sizes and shapes.

PROCEDURE

Original Thickness Measurement

10. The original average thickness of the test specimen shall be measured to the nearest 0.001 in. The specimen shall be placed on the small platform of the dial gage so that the pressure foot will indicate the thickness at the central portion of the top and bottom faces.

Application of Load

11. The test specimen shall be assembled in the compression device using extreme care to place it exactly in the center between the platens so that tilting may be avoided. The spring shall be compressed by tightening the screw until the deflection as read from the scale is equivalent to that shown on the calibration curve for the spring as corresponding to a load on the sample of 400 lb.

Heat Treatment

12. The assembled clamp shall be placed in the oven within 2 hr. after the completion of the assembly and shall remain there for 22 hr. in dry air at 70 C. (158 F.). At the end of the heating period the clamp shall be removed from the oven and the test specimen immediately taken from the clamp.

Cooling Period

13. While cooling, the test specimen shall rest on a wooden table top for 30 min. before the measurement of the final thickness is made.

Final Thickness Measurement

14. After the rest period, the final thickness shall be measured at the center of the test specimen using the dial gage described in Section 7.

Check Tests

15. Tests shall be run in duplicate but only one test specimen shall be tested at one time in each compression device. The duplicate test results should agree within ±5.0 per cent of the values obtained.

REPORT

Report

16. The report shall include the following:

(*a*) The original dimensions of the test specimen, including the original thickness, t_o.

(*b*) The actual load applied as determined from the calibrated curve of the spring and the spring deflection reading.

(*c*) Thickness of the test specimen 30 min. after removal from the clamp, t_1.

(*d*) The compression set in inches and the percentage of the original thickness.

$$\text{Compression Set} = t_o - t_1$$

$$\text{Percentage Compression Set} = \frac{(t_o - t_1)}{t_o} \times 100$$

A.S.T.M. Compression Set

17. The percentage compression set shall be known as the A.S.T.M. compression set number.

TENTATIVE SPECIFICATIONS
FOR
ASBESTOS ROVING[1]

A.S.T.M. Designation: D 375 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1933; REVISED, 1934.[2]

Scope

1. These specifications cover an asbestos textile product to be used as insulation on heat-resisting fixture wire, flexible cord or heater cord, and similar electrical conductors.

Roving

2. Roving, in the asbestos textile industry, is an assemblage of carded fibers rubbed into a single strand without twist.

Types

3. (*a*) *Asbestos Roving.*—Asbestos roving is composed of a mixture of chrysotile asbestos and cotton or other vegetable fiber.

(*b*) *Reinforced Asbestos Roving.*—Reinforced asbestos roving is composed of a core of cotton yarn covered with a mixture of chrysotile asbestos and vegetable fiber.

Grades

4. (*a*) Underwriters' Grade shall be not less than 80 per cent asbestos, by weight.

(*b*) Grade AA shall be not less than 90 per cent asbestos, by weight.

Varieties

5. Roving shall be made in two varieties, ferrous and non-ferrous.

Iron Content

6. (*a*) *Ferrous Roving.*—The total iron content of ferrous roving shall not exceed 6 per cent and the magnetic iron content shall not exceed 2 per cent of the weight of the dried sample.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.

[2] Revision accepted by Committee E-10 on Standards, August 22, 1934.

(*b*) *Non-Ferrous Roving.*—The total iron content of Underwriters' Grade non-ferrous roving shall not exceed 1.75 per cent of the weight of the dried sample; and of Grade AA it shall not exceed 2 per cent. The magnetic iron content of non-ferrous Underwriters' Grade roving shall not exceed 0.75 per cent; and of Grade AA it shall not exceed 1 per cent of the weight of the dried sample.

Sizes

7. The standard sizes of asbestos roving, designated as "cut," shall conform to the following requirements:

SIZE DESIGNATION	NOMINAL YARDAGE PER POUND	PERMISSIBLE VARIATION IN YARDAGE
5-cut	500	450 to 549
6-cut	600	550 to 649
7-cut	700	650 to 749
8-cut	800	750 to 849
9-cut	900	850 to 949
10-cut	1000	950 to 1049
12-cut	1200	1150 to 1249
14-cut	1400	1300 to 1499

NOTE.—The tolerances on special sizes such as 5½-cut, 6½-cut, etc., shall be equal to those of the standard sizes.

METHODS OF TESTING

Yards per Pound

8. Six cones, tubes or cheeses of roving shall be taken at random and five determinations of the number of yards per pound made on each package selected. The packages shall be grouped on the floor and six strands shall be drawn from them slowly, looping over a support to assemble 24 strands, which shall be cut into a 1-yd. length while suspended. The 24 yards shall be weighed to the nearest grain and the number of yards per pound calculated.

Asbestos Determination

9. (*a*) Five samples, each not less than 1 g., shall be dried to constant weight in weighed crucibles at 100 C. (212 F.). The dried samples shall then be ignited in an electric furnace at 800 C. (1472 F.) for 1 hr., and then cooled to room temperature in a desiccator. The weight of ash shall be divided by the factor 0.86[a] to obtain the original weight of the asbestos fiber. To obtain the percentage of asbestos, divide the weight of asbestos by the weight of the dried samples. The average of the five samples shall be the accepted determination.

---

[a] This factor is based on a proved average of 14 per cent water of crystallization in chrysotile asbestos.

(*b*) The asbestos determination of reinforced roving shall be made in accordance with Paragraph (*a*) without removing the cotton yarn.

Iron Determination

10. (*a*) The total iron content shall be determined by the potassium dichromate oxidation method.

(*b*) The percentage of magnetic iron shall be determined by the Mapes method.[1]

(*c*) Five determinations shall be made of samples taken from as many different packages, and the average shall be the accepted determination.

PACKING

Packing

11. Asbestos roving shall be supplied in the following three styles and dimensions of packages, the "cheese," the cone and the tube:

(*a*) *Cheese.*—Dimensions of the "cheese" packages shall be approximately 8 in. in outside diameter, 1½ in. in inside diameter and 2¼ in. in thickness.

(*b*) *Cone.*—The standard paper cone shall conform approximately to the following dimensions:

Inside diameter at base	1⅞ in.
Inside diameter at top	7/16 in.
Length	4½ in.
Thickness	⅛ in.
Diameter of winding at base	4½ in.
Traverse	4¼ in.

(*c*) *Tube.*—The standard paper tubes in two sizes shall conform approximately to the following dimensions:

Length, in	2¾	4¼
Inside diameter, in	1⅛	⅝
Thickness, in	⅛	⅛
Diameter of winding, in	4½	2½
Traverse, in	2½	4

Wrapping

12. All packages shall be individually wrapped in soft paper.

---

[1] *Asbestos*, p. 19, October, 1932.

TENTATIVE SPECIFICATIONS
FOR
ASBESTOS YARNS[1]

A.S.T.M. Designation: D 299 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Scope

1. These specifications define asbestos yarn, prescribe the methods of testing and stipulate tolerances.

Definitions

2. (*a*) *Asbestos Yarn.*—Asbestos yarn is yarn consisting of: (*1*) asbestos fiber, (*2*) asbestos and vegetable fibers, (*3*) asbestos and vegetable fibers and wire, or (*4*) asbestos and vegetable fibers with an insert of cotton or other yarn reinforcement.

(*b*) *Plain Asbestos Yarn.*—Plain asbestos yarn is yarn consisting of: (*1*) asbestos fiber, or (*2*) asbestos and vegetable fibers.

(*c*) *Metallic Asbestos Yarn.*—Metallic asbestos yarn is yarn consisting of plain asbestos yarn twisted with brass, copper or other fine wire. It is also termed "wire-inserted yarn."

(*d*) *Cut* (Asbestos).—A term indicating the size of asbestos yarn. The word "cut" preceded by a number indicates, in multiples of 100 yd., the yardage per pound of single-ply yarn. For example, "5-cut" indicates that a pound of single-ply yarn so designated measures approximately 500 yd.; "10-cut" indicates a yarn that measures approximately 1000 yd. per lb.

(*e*) *Ply.*—In the case of asbestos yarn, ply is the number of strands of single asbestos yarn twisted together to form a heavier yarn.

Example.—"2-ply 10-cut" indicates a yarn of two strands, each strand being 10-cut.

(*f*) *Yardage of Plied Asbestos Yarn.*—The yards per pound of plied plain asbestos yarn shall be determined by the following formula, which specifies the percentage to be deducted for twisting shrinkage:

$$\text{Nominal Yardage per Pound of Plied Asbestos Yarn} = \frac{\text{Nominal yards per pound of single-ply yarn}}{\text{Number of plies}} - 8 \text{ per cent}$$

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.

These Tentative Specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Asbestos Yarns (A.S.T.M. Designation: D 299 – 33), 1933 Book of A.S.T.M. Standards, Part II, p. 1161.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

Yardage

3. The yardage of plain, single-ply asbestos yarn shall conform to the following requirements:

SIZE DESIGNATION	NOMINAL YARDAGE PER POUND	PERMISSIBLE RANGE OF VARIATION IN YARDAGE
5-cut	500	450 to 549
6-cut	600	550 to 649
7-cut	700	650 to 749
8-cut	800	750 to 849
9-cut	900	850 to 949
10-cut	1000	950 to 1049
12-cut	1200	1150 to 1249
14-cut	1400	1300 to 1499
16-cut	1600	1500 to 1699
18-cut	1800	1700 to 1899
20-cut	2000	1900 to 2099
22-cut	2200	2100 to 2299
24-cut	2400	2300 to 2499
26-cut	2600	2500 to 2699
28-cut	2800	2700 to 2899
30-cut	3000	2900 to 3099

Size of Wire

4. The diameter of the wire used in metallic asbestos yarn shall not vary from the size specified more than ±0.001 in.

Grades

5. (*a*) The grades of both plain asbestos yarn and of metallic asbestos yarn shall be determined by the percentage of asbestos by weight and shall conform to the following requirements:

Commercial Grade	75 to but not including 80 per cent
Underwriters' Grade	80 to but not including 85 per cent
Grade A	85 to but not including 90 per cent
Grade AA	90 to but not including 95 per cent
Grade AAA	95 to but not including 99 per cent
Grade AAAA	99 to 100 per cent, inclusive

(*b*) The asbestos content of metallic asbestos yarn shall be determined after all the wire has been removed from the sample.

(*c*) The average determination of five samples shall designate the grade.

Asbestos Content Determination

6. Five samples of asbestos yarn, each not less than 1 g., shall be thoroughly cleansed of all oil, grease or sizing and then dried to constant weight in weighed crucibles at 100 C. (212 F.). The dried samples shall then be ignited in an electric furnace at 800 C. (1472 F.)

for 1 hr. and then cooled to room temperature in a desiccator and weighed. The weight of ash shall be divided by the factor 0.86[a] to obtain the original weight of the asbestos fiber. To obtain the percentage of asbestos, divide the weight of asbestos by the weight of the dried sample. The average of the five samples shall be the accepted determination.

Tensile Strength

7. (*a*) *Specified Tensile Strength.*—The average tensile strength of asbestos yarn shall be mutually agreed upon between the manufacturer and the purchaser.

(*b*) *Strength Tolerance.*—A permissible variation of minus ½ lb. shall apply to the specified tensile strength.

Method of Testing Strength

8. (*a*) *Testing Machine.*—The tensile strength of asbestos yarn shall be determined by testing single strands on testing machines such as described in the Standard Specifications for Textile Testing Machines (A.S.T.M. Designation: D 76) of the American Society for Testing Materials.[1]

(*b*) All tests shall be made of single strands. Single strands shall be broken after conditioning the tubes or bobbins for 12 hr. in an atmosphere of 65 per cent relative humidity at 70 F. (21 C.). A single-strand tester of proper capacity with the jaws set 10 in. between grips and having a speed of pulling jaw of 12 in. per min. shall be used. The average of four breaks from each of ten tubes or bobbins shall be the average strength.

---

[a] This factor is based upon a proved average of 14 per cent water of crystallization in chrysotile asbestos.

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 1198.

TENTATIVE SPECIFICATIONS
FOR
HOLLAND CLOTH[1]

A.S.T.M. Designation: D 376 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1933; REVISED, 1934.

Scope

1. These specifications cover No. 1 and No. 2 constructions of Holland cloth for use in the tire industry.

Properties

2. Holland cloth shall conform to the requirements specified in Table I, subject to the tolerances specified therein.

TABLE I.—PHYSICAL PROPERTIES OF HOLLAND CLOTH.

	No. 1 Construction	No. 2 Construction	Tolerances No. 1 and No. 2 Constructions
Width (trimmed), in.	as specified	as specified	±$\frac{1}{4}$
Weight, oz. per sq. yd.	4.8	4.6	±0.2
Count: Warp	74	56	±4
Count: Filling	64	46	±4
Thickness (Gage), in.	0.005	0.0045	±0.0005
Length of Roll, yd.	300	300	±30

Tolerances

3. Tolerances shall be the limits within which a textile must come in its specified characteristics in order that it shall constitute a good delivery on contract. They may be classified as the allowable limits of the quantitative characteristics of the fabric as defined in the specifications.

SPECIAL REQUIREMENTS

Defects

4. Holland cloth shall have a smooth surface, shall not bag in the center, shall not have loose or wavy edges, shall not be cockled or wrinkled, or have any other defects which will mar the fabric or interfere with recognized factory processes.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.

Porosity

5. Holland cloth shall contain no pinholes or pores through which rubber will pass when under pressure.

Finish

6. When Holland cloth is applied to a tacky gum surface under conditions similar to those existing in commercial practice and is then snapped or plucked from the gum stock, there shall be no starch particles left adhering to the gum surface. Rejections for this defect shall be made within 30 days of receipt of the material. It is understood that this requirement applies to No. 1 construction only.

Splices

7. Splices shall not be more than 4 in. in width and shall be strong enough to resist pulling apart at any point. Calendered splices shall be used unless otherwise specified.

Selvage

8. Holland cloth shall be trimmed on both edges so that no selvage is present.

Shells

9. Shells shall consist of heavy paper tubes $\frac{3}{16}$ in. in thickness and $1\frac{1}{4}$ in. in inside diameter, unless otherwise specified.

Roll Edges

10. Each roll shall be tightly and evenly wound so that both edges are even throughout.

Wrapping

11. Rolls shall be wrapped with moisture-proof paper and sealed in a manner that protects the material from excess moisture in the air.

Packing

12. Rolls shall be packed in a suitable container and in a manner that will prevent slippage of the material on itself or damage to the edges. Containers shall be of such size as to hold approximately 1200 yd. of material, or four rolls.

Length of Cuts or Pieces

13. No roll shall contain more than three splices and no piece shall be less than 15 yd. in length.

Shortage

14. Shortage in excess of 0.5 per cent of the total billed yardage of any shipment will be charged back to the shipper at full contract price.

METHODS OF TESTING

Width

15. The average width shall be determined by measuring at five different places uniformly distributed along the full length of the roll or piece. No measurement shall be considered within 3 yd. of either end of the roll or piece.

Weight

16. The weight per square yard shall be determined in accordance with Sections 3 and 7 of the Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39) of the American Society for Testing Materials.[1]

Count

17. The average number of ends and picks per inch of the fabric shall be determined by counting a space not less than 1 in. in five different places uniformly distributed along the full length of the roll or piece. No count shall be considered within 3 yd. of either end of the roll or piece, or within 6 in. of the edge of the roll or piece.

Thickness (Gage)

18. The average thickness of the fabric shall be determined by means of an automatic micrometer equipped with a foot $\frac{3}{8}$ in. in diameter. The foot of the micrometer shall be raised $\frac{1}{4}$ in. above the fabric and allowed to drop under a dead weight pressure of 6 oz. Thickness measurements shall be made in five different places uniformly distributed along the full length of the roll or piece. No determination shall be considered within 3 yd. of either end of the roll or piece or within 6 in. of the edge of the roll or piece.

Length of Roll

19. The length of a roll or piece shall be determined by running the cloth over a measuring drum of known circumference, from which the yardage is registered by a dial or counter driven by a chain, or other positive or non-slip mechanism. Just enough uniform tension shall be used on the cloth to keep it running flat and true.

---

[1] 1934 Supplement to Book of A.S.T.M. Standards, p. 204.

TENTATIVE SPECIFICATIONS
FOR
TOLERANCES AND TEST METHODS FOR WOOLEN YARNS[1]

A.S.T.M. Designation: D 403 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Scope

1. These specifications for tolerances and test methods apply to single or plied woolen yarns of any of the following three types:

Scoured Spun in Oil Yarn, made from thoroughly scoured wool to which oil has been added;

Semiscoured Spun in Oil Yarn, made from wool which has been washed at the source but not scoured, and to which oil has been added;

Dry Spun Yarn, made from thoroughly scoured wool without the addition of oil.

Materials and Workmanship

2. The yarn shall be reasonably clean and free from slubs and shall be reasonably uniform in diameter in view of the purpose for which it is to be used.

Definitions

3. (*a*) *Direction of Twist.*—The direction of twist shall be as defined in the Tentative Definitions and Terms Relating to Textile Materials (A.S.T.M. Designation: D 123 - 34 T) of the American Society for Testing Materials.[3]

(*b*) *Standard Regain.*—The standard regain for woolen yarn is 13 per cent, which is equivalent to 11.5 per cent moisture content.

TOLERANCES

Tolerances

4. Woolen yarn shall conform to the following tolerances:

(*a*) *Weight.*—The net weight of the shipment of yarn shall be calculated to the basis of standard regain.

(*b*) *Yarn Number.*—The yarn number shall be as specified, ± 10 per cent for single yarns or ± 5 per cent for plied yarns, unless other tolerances are stated in the contract.

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

[3] See p. 1199.

(*c*) *Twist.*—The average twist of yarn from all of the packages tested shall not vary more than ±7½ per cent from the specified twist. The average twist of yarn from any one package shall not vary more than ±7½ per cent from the average for any other package in the shipment.

(*d*) *Direction of Twist.*—The direction of twist shall be as specified.

(*e*) *Breaking Strength.*—The breaking strength of yarn shall be not less than that specified.

(*f*) *Fat Content.*—Scoured spun in oil yarn shall contain not more than 7 per cent of fat; semiscoured spun in oil yarn, not more than 15 per cent of fat; and dry spun yarn, not more than 2 per cent of fat.

METHODS OF TESTING

Sampling

5. (*a*) Samples shall be so selected as to be fairly representative of the shipment.

(*b*) For yarn on cones, spools, or bobbins, four cones, spools, or bobbins shall be selected from each case of yarn.

(*c*) For yarn on beams, each beam of yarn shall be tested separately.

Conditioning of Samples

6. Before testing the yarn for yarn number or for breaking strength, samples shall be conditioned by exposing them to an atmosphere of 65 ±2 per cent relative humidity and 70 to 80 F. (21 to 27 C.) for not less than 12 hr. when the yarn is on cones, tubes, or bobbins, and not less than 3 hr. when the yarn is in skeins.

Preparation of Skeins

7. (*a*) *Skeins for Yarn Number Test.*—Skeins for the determination of yarn number shall be prepared by winding the yarn on a reel having a perimeter of 1½ yd. The standard skein shall contain 120 yd. requiring 80 turns of the reel.

(*b*) *Winding Skeins.*—During the winding, care must be used to maintain the proper tension in the yarn. If the reel is equipped with one guide, the yarn shall make one full turn around the guide; if it has two guides, the yarn shall pass straight through the guides. For yarn on cones where the yarn is drawn from the top, the speed of the reel shall be 100 to 300 r.p.m. For yarn on tubes where the yarn is drawn from the side, the speed of the reel shall be 20 to 30 r.p.m. For yarn on beams, the reel and the beam shall be turned by hand by different operators at such speeds that the yarn shall be wound on the reel as fast as it is unwound from the beam, with maintenance of the proper tension. It is preferable to equip yarn reels with motors.

Yarn Number

8. A skein prepared as described in Section 7 and after conditioning in accordance with Section 6 shall be weighed to the nearest grain and the yarn number calculated. The yarn number shall be the average of the results found for 12 skeins from each beam or case of yarn, not more than 3 of which may be taken from any one cone or tube.

Fat Content

9. (*a*) A 5-g. sample (approximate) shall be dried to constant weight (within 1 mg.) at 212 to 221 F. (100 to 105 C.) and then weighed. It shall then be extracted in a Soxhlet flask for 2 hr. with c.p. ethyl ether. The extract shall be evaporated in a weighed dish until the odor of ether is no longer noticeable and then weighed. The difference between this weight and the weight of the dish is the fat content.

(*b*) Duplicate samples shall be tested from each case or beam of yarn. If the two determinations do not check, or if the average results fail to conform to the specification requirements, two additional samples shall be tested from the same case or beam from which the original samples were taken.

Regain Determination

10. (*a*) Three samples of not less than 200 g. each shall be selected and weighed at the same time and under the same conditions as the bulk of the yarn which the samples represent. These samples shall then be placed in a conditioning oven at a temperature of 220 to 230 F. (104 to 110 C.). When no change in weight is noted in three consecutive weighings at 10-min. intervals, the yarn shall be considered "oven dry."

(*b*) The difference between the average of the original (initial) weights of the sample and the average of the oven-dry weights of the same shall be considered as the "moisture loss."

(*c*) The percentage regain equals the moisture loss multiplied by 100 and divided by the average oven dry weight.

Packing and Marking

11. Each case, beam, or other package of yarn shall be plainly marked with the name of the vendor, the net and gross weights, and some means of identifying the contract under which it was delivered.

Rejection

12. Yarn may be rejected if it fails to meet any of the requirements of these specifications. In case of rejection, the vendor must be notified within 10 days of the shipment.

TENTATIVE SPECIFICATIONS
FOR
TOLERANCES AND TEST METHODS FOR WORSTED YARNS[1]

A.S.T.M. Designation: D 404 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Scope

1. These specifications for tolerances and test methods apply to single or plied worsted yarns for any of the following two types:

Dry Spun Yarn, made from dry combed tops;

Oil Spun Yarn, made from oil combed tops.

Materials and Workmanship

2. The yarn shall be reasonably clean and free from slubs and shall be reasonably uniform in diameter in view of the purpose for which it is to be used.

Definitions

3. (*a*) *Yarn Number.*—The size of worsted yarn shall be specified in terms of the number of 560-yd. hanks per pound (English System).

(*b*) *Direction of Twist.*—The direction of twist shall be as defined in the Tentative Definitions and Terms Relating to Textile Materials (A.S.T.M. Designation: D 123 - 34 T) of the American Society for Testing Materials.[3]

(*c*) *Standard Regain.*—The standard regain of worsted yarn is 15 per cent for dry spun and 13 per cent for oil spun, which is equivalent to 13.04 per cent and 11.5 per cent moisture contents, respectively.

TOLERANCES

Tolerances

4. Worsted yarns shall conform to the following tolerances:

(*a*) *Weight.*—The net weight of the shipment of yarn shall be calculated to the basis of standard regain.

(*b*) *Yarn Number.*—The yarn number shall be as specified within the following permissible variations:

---

[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

[3] See p. 1199.

		PERMISSIBLE VARIATIONS IN YARN NUMBER
Single yarns	Coarser than 21's	±5 per cent
	21's to 31's	±3.5 per cent
	31's to 41's	±3 per cent
	41's and finer	±2.5 per cent
Plied yarns		±2.5 per cent

(*c*) *Twist.*—The average twist of yarn from all of the packages tested shall not vary more than ±7½ per cent from the specified twist. The average twist of yarn from any one package shall not vary more than ±7½ per cent from the average for any other package in the shipment.

(*d*) *Direction of Twist.*—The direction of twist shall be as specified.

(*e*) *Breaking Strength.*—The breaking strength of yarn shall be not less than that specified.

(*f*) *Fat Content.*—Dry spun yarns shall contain not more than 1½ per cent of fat, and oil spun yarns not more than 4 per cent of fat.

METHODS OF TESTING

Sampling

5. (*a*) Samples shall be taken at random from the shipment.

(*b*) For yarn on cones, spools, or bobbins, seven cones, spools, or bobbins shall be selected from each case of yarn.

(*c*) For yarn on beams each beam of yarn shall be tested separately.

Conditioning of Samples

6. Before testing the yarn for yarn number or for breaking strength, samples shall be conditioned by exposing them to an atmosphere of 65 ±2 per cent relative humidity and 70 to 80 F. (21 to 27 C.) for not less than 12 hr. when the yarn is on cones, tubes, or bobbins, and not less than 3 hr. when the yarn is in skeins.

Preparation of Skeins

7. (*a*) *Skeins for Yarn Number Test.*—Skeins for the determination of yarn number shall be prepared by winding the yarn on a reel having a perimeter of 1 yd. The standard skein shall contain 560 yd. requiring 80 turns of the reel for 7 bobbins or spools.

(*b*) *Skeins for Breaking Strength Test.*—Skeins for the determination of breaking strength shall be prepared by winding the yarn on a reel having a perimeter of 1½ yd. This skein shall contain 120 yd. requiring 80 turns of the reel.

(*c*) *Winding Skeins.*—During the winding, care must be used to maintain the proper tension in the yarn. If the reel is equipped with one guide, the yarn shall make one full turn around the guide; if it has two guides, the yarn shall pass straight through the guides. For yarn on cones where the yarn is drawn from the top, the speed of the reel shall be 100 to 300 r.p.m. For yarn on tubes where the yarn is drawn from the side, the speed of the reel shall be 20 to 30 r.p.m. For yarn on beams, the reel and the beam shall be turned by hand by different operators at such speeds that the yarn shall be wound on the reel as fast as it is unwound from the beams, with maintenance of the proper tension. It is preferable to equip yarn reels with motors.

Yarn Number

8. A skein prepared as described in Section 7 and after conditioning in accordance with Section 6 shall be weighed to the nearest grain and the yarn number calculated. The yarn number shall be the average of the results found for 12 skeins from each beam or case of yarn, not more than 3 of which may be taken from any one cone or tube.

Fat Content

9. (*a*) A 5-g. sample (approximate) shall be dried to constant weight (within 1 mg.) at 212 to 221 F. (100 to 105 C.) and then weighed. It shall then be extracted in a Soxhlet flask for 2 hr. with c.p. ethyl ether. The extract shall be evaporated in a weighed dish until the odor of ether is no longer noticeable and then weighed. The difference between this weight and the weight of the dish is the fat content.

(*b*) Duplicate samples shall be tested from each case or beam of yarn. If the two determinations do not check, or if the average results fail to conform to the specification requirements, two additional samples shall be tested from the same case or beam from which the original samples were taken.

Regain Determination

10. (*a*) Three samples of not less than 200 g. each shall be selected and weighed at the same time and under the same conditions as the bulk of the yarn which the samples represent. These samples shall then be placed in a conditioning oven at a temperature of 220 to 230 F. (104 to 110 C.). When no change in weight is noted in three consecutive weighings at 10-min. intervals, the yarn shall be considered "oven dry."

(*b*) The difference between the average of the original (initial) weights of the sample and the average of the oven-dry weights of the same shall be considered as the "moisture loss."

(*c*) The percentage regain equals the moisture loss multiplied by 100 and divided by the average oven dry weight.

Packing and Marking

11. Each case, beam, or other package of yarn shall be plainly marked with the name of the vendor, the net and gross weights, and some means of identifying the contract under which it was delivered.

Rejection

12. Yarn may be rejected if it fails to meet any of the requirements of these specifications. In case of rejection, the vendor must be notified within 10 days of the shipment.

TENTATIVE METHOD OF ESTIMATING HARD SCOURED WOOL IN WOOL IN THE GREASE[1]

A.S.T.M. Designation: D 232 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1925; Revised, 1934.[2]

Scope

1. This method of test is intended for estimating hard scoured wool in wool in the grease and is applicable to any shipment of wool in the grease, whether in the form of fleeces, necks, pieces, bellies, pulled wool, or colonial scoured. It is also applicable to shipments of similar hairs such as mohair, alpaca, camel hair, cashmere, and vicuna.

Standard Regain

2. The standard regain of hard scoured wool is 13.64 per cent which is equivalent to 12 per cent moisture content.

Sampling

3. The entire shipment shall be sorted into the different kinds or grades of wool which it contains. The total net weight of each kind or grade shall be recorded separately. A sample of not less than 5 per cent of the lot, and in no case less than 500 lb., shall be selected as representative of each kind or grade of wool.

Scouring

4. (*a*) Each sample shall be scoured separately in a commercial type of scouring equipment having not less than four bowls and using an alkaline detergent, or using a solvent extraction process. The sample shall be air-dried after scouring.

(*b*) The sample shall be considered as having been properly scoured when it conforms to the following requirements:

Free Fat, max., per cent	fine wools (64's and fines)	1
	medium and heavier wools (¼ to ⅜ blood and coarser)	1½
Soap Fat, max., per cent		1
Ash, max., per cent	fine or medium wools	1
	coarse wools	3

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-13 on Textile Materials.

[2] Revision accepted by Committee E-10 on Standards, August 22, 1934.

Free Fat

5. A sample of approximately 5 g. of scoured wool shall be accurately weighed and then extracted in a Soxhlet apparatus for 20 extractions with c.p. ethyl ether. The ether shall then be evaporated from the extract and the residue dried to constant weight at 212 to 221 F. (100 to 105 C.), and the final weight recorded. This residue is the free fat.

Soap Fat

6. The sample from which the free fat has been removed (Section 5) shall be extracted in a Soxhlet apparatus for 12 extractions with neutral 95 per cent alcohol. The alcohol shall then be evaporated from the extract. After adding 25 to 30 cc. of 0.1 *N* HCl this shall be boiled and cooled. The solution shall then be shaken with an equal volume of neutral ether and decanted. This shall be repeated twice. The three ether extracts shall be combined and washed once by shaking with an equal volume of distilled water and decanted. The ether shall then be evaporated from the extract and dried to constant weight at 212 to 221 F. (100 to 105 C.), and the final weight recorded. This residue is the soap fat.

Ash

7. A 2 to 3-g. sample of scoured wool shall be accurately weighed. The sample shall then be ignited to constant weight in a porcelain crucible and the final weight recorded. This residue is the ash.

NOTE.—Wool is apt to swell and froth when heated. To avoid loss, the sample may be burned in small portions, or it may be moistened with a saturated solution of ammonium nitrate in 67 per cent alcohol.

Moisture

8. A sample of approximately 200 g. of scoured wool shall be accurately weighed and then dried to constant weight at 220 to 230 F. (104 to 110 C.). The final weight shall be recorded.

Calculation of Results

9. (*a*) From the results obtained in Section 8, determine the percentage of moisture in the scoured sample. Calculate the weight of the scoured sample under conditions of standard regain. Calculate the percentage of scoured wool with standard regain on the basis of the weight of the sample before scouring. Multiply this percentage by the net weight of the wool represented by the sample to find the amount of scoured wool contained in the greasy wool tested.

(*b*) The results of all determinations for free fat, soap fat, and ash in the wool shall be expressed at standard regain.

TENTATIVE DEFINITIONS AND TERMS RELATING TO TEXTILE MATERIALS[1]

A.S.T.M. Designation: D 123 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE, 1921; ADOPTED IN AMENDED FORM, 1927; REVISED, 1930; REISSUED AS TENTATIVE, 1933; REVISED, 1934.

Abacá.—See Fibers, Vegetable.

African Sisal.—Under Fibers, Vegetable, see Sisal.

Airplane Fabric (Cotton).—A plain-weave fabric well woven, practically without imperfections, of mercerized two-ply yarns, width 36 to 56 in., maximum weight 4.5 oz. per sq. yd., and threads per inch warp and filling 80 to 84.

Ambari.—Under Fibers, Vegetable, see Kenáf.

Asbestos Roving.—Asbestos roving is composed of a mixture of chrysotile asbestos and cotton or other vegetable fiber.

> *Reinforced Asbestos Roving.*—Reinforced asbestos roving is composed of a core of cotton yarn covered with a mixture of chrysotile asbestos and vegetable fiber.

Asbestos Yarn.—Yarn consisting of: (1) asbestos fiber; (2) asbestos and vegetable fibers; (3) asbestos and vegetable fibers and wire; or (4) asbestos and vegetable fibers with an insert of cotton or other yarn reinforcement.

> *Plain Asbestos Yarn.*—Yarn consisting of: (1) asbestos fiber, or (2) asbestos and vegetable fibers.
>
> *Metallic Asbestos Yarn.*—Yarn consisting of plain asbestos yarn twisted with brass, copper or other fine wire. It is also termed "wire inserted yarn."

Bad Casts (Raw Silk).—Abruptly thickened places on the threads due to the cocoon filament not being properly attached to the thread, or made by adding more than one cocoon filament at a time.

Bagging.—A very heavy loosely woven fabric used for bale tares, etc., woven from heavy tight-twisted roving, consisting largely of reworked and waste fibers. Also known as "gunny."

---

[1] Under the standardization procedure of the Society, these definitions are under the jursidiction of the A.S.T.M. Committee D-13 on Textile Materials.

These tentative definitions comprise a revision and combination of the former Standard Definitions of Terms Relating to Textile Materials (A.S.T.M. Designation: D 123 - 30) and Tentative Definitions of Terms Relating to Textile Materials (A.S.T.M. Designation: D 123 - 30 T), which definitions were accordingly discontinued in 1933.

Bahama Sisal.—Under Fibers, Vegetable, see Sisal.

Benares Sunn.—Under Fibers, Vegetable, see Sunn.

Bimlipatam Jute.—Under Fibers, Vegetable, see Kenáf.

Binder Twine.—A somewhat stiff, single strand yarn, 3 to 4 mm. in diameter, made of hard fibers (henequen, sisal, abacá, or phormium), used chiefly for binding bundles of grain, etc.

Boiled-Off Silk.—Silk with the gum (sericin) removed.

Bombay Aloe.—Under Fibers, Vegetable, see Cantara and Piteira.

Book-Fold.—The fabric is doubled selvage to selvage, then folded back and forth upon itself in predetermined lengths. When the piece is completed, the fold-edges on each side are folded to the center and the piece is folded once more upon itself so that the fold-edges are inside, forming a compact package as long as one-half the width of the goods.

Broken Pick.—A streak across the width of the fabric caused by a completely or partially missing pick.

Brown Hemp.—Under Fibers, Vegetable, see Sunn.

Burlap (Jute).—A coarse, heavy, plain-weave fabric of coarse single yarn.

Cable Twist.—A twine, cord, or rope construction in which each successive twist is in the opposite direction to the preceding twist.

Cantala.—See Fibers, Vegetable

Cellulose-Acetate Rayon.—See Fibers, Artificial.

China Grass.—See Fibers, Vegetable.

China Hemp.—Under Fibers, Vegetable, see Hemp.

Chingma.—See Fibers, Vegetable.

Cockled or Cockling.—A curliness or crimpiness appearing in fabrics when different sizes of yarn or varying tensions on the yarns are accidentally introduced.

Coir.—See Fibers, Vegetable.

Cordage.—A term used in a collective sense to include all sizes and varieties of twines, cords, ropes and cables of textile materials.

Cordage Fibers.—See Fibers, Cordage.

Corkscrews (Raw Silk).—A place in the thread in which one or more cocoon filaments are longer than the remainder and give the appearance of a spiral form.

Heavy Corkscrews (Raw Silk).—Corkscrews which are more than twice the diameter of the thread.

Corkscrew Twist.—A place in the yarn or cord where an uneven twist gives a corkscrew-like appearance.

Cotton.—See Fibers, Vegetable.

Crimp.—The difference in distance between two points on a yarn as it lies in a fabric and the same two points when the yarn has been removed from the fabric and straightened, expressed as a percentage of the distance between the two points as the yarn lies in the fabric.

Cuprammonium Rayon.—See Fibers, Artificial.

Cut (Asbestos).—A term indicating the size of asbestos yarn. The word "cut" preceded by a number indicates, in multiples of 100 yd., the yardage per pound of single-ply yarn. For example, "5 cut" indicates that a pound of single-ply yarn so designated measures approximately 500 yd.; "10 cut" indicates a yarn that measures approximately 1000 yd. per lb.

(Woolen).—See Yarn Number (Woolen—Cut).

Da or Dha.—Under Fibers, Vegetable, see Kenáf.

Daisee Jute.—Under Fibers, Vegetable, see Jute.

Defective Splice.—A splice having irregular final twist, untrimmed ends, or excessive thickness or thinness.

Denier.—A unit of weight (0.05 g.) used to express the size of silk and rayon. The weight in units of 0.05 g. of a 450-m. skein at standard conditions is the denier of silk and rayon (exclusive of spun silk and staple rayon) yarn. It is also equal numerically to the weight in grams of a 9000-m. skein at standard conditions.

Dungaree (Cotton).—A heavy cloth woven in the 2/1 twill weave from dyed warp and filling yarns, in narrow widths, usually 28 in.; approximate number of threads per inch, warp 68 and filling 52; yarn number both warp and filling 20's.

End.—An individual warp yarn.

Felt Jackets.—See Jackets.

Fiber.—A slender, elongated filament, such as rayon, silk, or wool; or a single elongated cell, like cotton or kapok; or a slender strand composed of aggregations of elongated cells like flax, jute and sisal.

Fibers, Artificial:

Cellulose-Acetate Rayon.—Filaments composed of an acetic ester of cellulose which has been coagulated or solidified from its solution.

Cuprammonium Rayon.—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose in ammoniacal copper oxide.

Nitrocellulose Rayon (Chardonnet).—Filaments composed of a regenerated or denitrated cellulose which has been coagulated or solidified from a solution of nitrated cellulose.

Viscose Rayon.—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose xanthate.

Fibers, Cordage.—Coarse hard fibers, such as abacá, sisal, henequen, cantala, phormium, palma and piteira (see Fibers, Vegetable), used in the manufacture of ropes and coarse twines. Generally too coarse and stiff to be woven into fabrics.

Fibers, Hard or Leaf.—Rather stiff elongated strands from leaves like sisal, henequen, and piteira (see Fibers, Vegetable), or leaf stems like abacá, used chiefly in coarse twines, ropes and heavy cordage.

Fibers, Soft or Bast.—Flexible elongated strands from the inner bark of plants like flax, hemp, jute and ramie, used in twines, nets and woven fabrics.

Fibers, Textile.—Slender filaments or strands that cling together, enabling them to be spun into yarns of appreciable strength and sufficiently pliable to be woven or knitted into fabrics. Essential requisites are tensile strength, length of at least 5 mm. and more than 100 times the diameter, pliability and cohesiveness; desirable, but not essential, properties are elasticity, fineness, uniformity, durability and luster. Textile fibers include cotton, flax, jute, and many other fibers of vegetable origin; silk, wool and various hairs of animal origin; rayon and allied synthetic or artificial fibers; and asbestos of mineral origin.

Fibers, Vegetable:

Abacá (a-ba-ká).—A hard fiber, rather coarse, firm texture, cream-white to brown in color, 150 to 350 cm. long, strong and durable from the leaf stems forming the trunk of the abacá plant, *Musa textilis,* cultivated in the Philippine Islands, Sumatra, Java and Borneo; used in ropes and coarse twines and cordage, especially marine cordage, oil-well cables, and binder twine. Called "Manila hemp" in the market, but quite unlike true hemp, also called "Cebu hemp" and "Davao hemp."

Cantala.—A hard fiber, finer, softer and weaker than sisal, yellow-white to brownish white, 75 to 150 cm. long, from leaves of the cantala plant, *Agave cantala*, cultivated in the Philippine Islands, Java, Sumatra and India; used in coarse twines including binder twine. Called "Manila maguey" and "Cebu maguey" in market quotations for water-retted, hand-cleaned cantala of the Philippine Islands.

Fibers, Vegetable (Continued):

China Grass.—Ramie fiber separated from the stalk and the thin outer bark, but not degummed; the form in which it is usually exported from China.

Chingma (Ching′-mah).—A rather coarse soft fiber, usually flaggy and fuzzy, straw-white, from the inner bark of the chingma plant, *Abutilon theophrasti*, cultivated in northern China and Japan. Called "China jute" and "Tientsin jute," but it is not a true jute.

Coir.—A hard fiber, usually brown, 10 to 25 cm. long, from the outer husk of the cocoanut, *Cocos nucifera*, produced chiefly in Ceylon and southern India; used in door mats and as a stuffing fiber in upholstery.

Cotton.—Fine, one-celled, twisted fibers, white or in some types tawny, brown or green, 20 to 50 mm. long, growing on the seeds of several different species of the genus *Gossypium*; used more than all other vegetable fibers, and for a wider range of purposes including yarns, twines, woven and knit goods, upholstery stuffing and packing.

American short-staple upland cotton.—Fiber 20 to 27 mm. long, from *Gossypium hirsutum*, cultivated in the southern part of the United States and introduced into nearly all cotton-growing countries.

American long-staple upland cotton.—28 to 40 mm. long, from selected varieties of *Gossypium hirsutum*, cultivated largely in the Yazoo-Mississippi delta. Also called "delta cotton."

Arizona Egyptian cotton.—Fiber 35 to 45 mm. long, from modified forms of *Gossypium barbadense*, cultivated in Arizona and southern California, includes "Pima cotton."

Egyptian cotton.—Fiber 30 to 40 mm. long, white or in some varieties light brown, from modified forms of *Gossypium barbadense*, cultivated chiefly in lower Egypt, includes "Sakellarides," "Zagora," etc.

India cotton.—Short staple, 18 to 25 mm. long, from *Gossypium neglectum*, cultivated in India.

Levant cotton.—Short staple, 18 to 25 mm. long, from *Gossypium herbaceum*, cultivated in Asia Minor and countries bordering the Mediterranean Sea.

Fibers, Vegetable (Continued):

Rough Peruvian cotton.—A rather harsh, wiry cotton, from *Gossypium peruvianum*, cultivated in Peru, used chiefly for mixing with wool.

Sea island cotton.—Fine fiber, 30 to 50 mm. long, from *Gossypium barbadense*, cultivated chiefly in the West Indies, used in the finest cotton yarns.

Flax.—A soft, fine fiber, dark gray, bluish green, brown or cream white, 40 to 100 cm. long, from the inner bark of the fiber flax plant, *Linum usitatissimum*, cultivated chiefly in northern Europe; used in linen thread, shoe thread, seine twine, sacking twine, laces, table linen, handkerchiefs, towels and in all true linens.

Courtrai flax.—Flax fiber of superior quality, very carefully prepared from straw retted in the River Lys, or most of it in recent years tank-retted in the vicinity of Courtrai, Belgium.

Dew-retted flax (Slanetz of Russia).—Flax fiber prepared by spreading the plants on the ground and exposing to the weather for retting.

Flax tow.—Short or tangled fiber beaten out in scutching—often called scutching tow; or combed out in hackling and called machine tow; used in flax yarns and twines. (This flax tow is distinctly different from upholstery flax tow.)

Flemish flax.—Flax produced in Flanders (northeastern France and Belgium).

Hackled flax (also called "dressed flax" or "dressed line").—Flax fiber, which after being scutched, has been cleaned further by combing over hackles.

Irish flax.—Flax fiber produced in northern Ireland, mostly retted in bogs, yielding a very strong fiber.

Risten (*R* in market quotations).—The standard grade of flax on which other grades of the Baltic countries are based.

Water-retted flax (Motchenetz of Russia).—Flax fiber, light cream-white to gray in color, prepared by retting the plants in water.

Fibers, Vegetable (Continued):

Hemp.—A soft fiber, dark steel gray to cream-white, usually in narrow flat ribbons, 100 to 250 cm. long, from the inner bark of the hemp plant, *Cannabis sativa*, cultivated in Italy, Soviet Republic, Yugoslavia, Hungary, China, Japan, Chile, Wisconsin, Illinois and Kentucky; used in America in commercial twines, marlines, halyards and tarred rigging.

Hemp line.—Hemp fiber, scutched and prepared so that the fibers lie straight and parallel.

Hemp tow.—Short or tangled hemp fiber, beaten out in scutching the long fiber, or hemp fiber produced from short or tangled stalks.

Italian hemp.—Hemp fiber produced in Italy, mostly water-retted and well prepared and graded.

Kentucky rough prime.—The best quality of Kentucky dew-retted hemp, broken on hand brakes, but not hackled.

Kentucky single-dressed.—Kentucky hemp further prepared by drawing it over a coarse hackle.

Russian hemp.—Hemp fiber chiefly dew-retted and prepared by hand in the Soviet Republic.

Wisconsin hemp.—Hemp fiber produced in Wisconsin by dew-retting and breaking and scutching by machinery.

Henequen (hen-e-ken′).—A hard fiber, rather coarse, of firm texture, light yellow or sometimes reddish yellow, cylindrical, 75 to 150 cm. long, from the leaves of the henequen plant, *Agave fourcroydos*, cultivated in the Yucatan peninsula, and in Tamaulipas in Mexico and in Cuba; used chiefly in binder twine and in other coarse twines and small ropes.

Istle (eest′-ley).—Hard fibers, light yellow, 20 to 50 cm. long, cylindrical and stiff, from the leaves of two closely related species of *Agave*, growing without cultivation in Mexico, used chiefly in brushes, and to a less extent in twines; used in Mexico for handmade twines and coarse sacks. Also called "Tampico" and "Mexican Fiber."

Jute.—Soft fibers, light yellow to nearly white or bright copper to deep slate, changing in age to dingy brown or gray, 100 to 500 cm. long, averaging about 240 cm. exclusive of butts,

Fibers, Vegetable (Continued):

Jute (Continued):

from the inner bark of the round-pod jute, *Corchorus capsularis*, and the long-pod jute, *Corchorus olitorius*, cultivated in India, chiefly in Bengal, and to a very limited extent elsewhere in southern Asia and in tropical Africa; used in twines, gunnies, burlaps, hessians, carpet yarns, sacks for sugar, coffee, grain, feed, fertilizer and wool, and backing for linoleum and oilcloths.

Jute butts.—The flaggy lower ends of jute fiber, 10 to 25 cm. long, cut off in preparing jute for market, used in twines and coarse bagging, especially in covering for bales of cotton.

Daisee jute (also spelled *desi* and *deshi*, meaning "local").—Fiber of long-pod jute, *Corchorus olitorius*, grown in the brackish soils in the region of Calcutta, generally ranging from copper brown to slate gray.

Tossa jute.—Fiber of long-pod jute, *Corchorus olitorius*, grown on uplands in eastern India; pearl gray to deep slate color or copper brown.

Kapok.—Stuffing fiber or down, composed of single cells, 20 to 30 mm. long, white gray or tawny in color, produced in the seed pods of the kapok tree, *Ceiba pentandra*, and closely allied species of the bombax family, resistant to the absorption of moisture, resilient and buoyant; used as stuffing in pillows, mattresses and life preservers and for temperature and sound insulation.

Kenáf.—A soft jute-like fiber, light yellow to gray, flaggy at base, 150 to 250 cm. long, from the inner bark of the kenáf plant, *Hibiscus cannabinus*, cultivated most extensively in Persia and Trans-Caspian Russia. Called "Da" in French West Africa, "Gombo" in Portuguese Africa, "Ambari" and "Deccan Hemp" in India, "Bimlipatam" in Madras Presidency; used in twines and for purposes similar to jute.

Mescal Maguey.—A hard fiber, light straw-yellow, slightly finer and softer than sisal, 80 to 150 cm. long, from leaves of the mescal maguey plant, *Agave pseudotequilana*, cultivated in western Mexico; used in twines and cordage.

Fibers, Vegetable (Continued).

Palma.—A hard fiber nearly white or light brownish yellow, often with some coarser dark brown curved ends, 25 to 50 cm. long, from the leaves of a tree yucca, *Samuela carnerosana*, growing on high mountains in northern Mexico; used for twines, especially "paper twines." Also called "palma istle," but quite unlike istle fibers.

Phormium (for′-mi-um).—A hard fiber, reddish yellow or nearly white, finer and softer than abacá, 150 to 300 cm. long, from the leaves of the harakeke lily, *Phormium tenax*, growing wild and cultivated in New Zealand, and cultivated in St. Helena; used chiefly in hard fiber twines, including binder twine. Called "New Zealand hemp" and "New Zealand flax" but the fiber is unlike hemp or flax.

Piteira (pe-ter′-a).—A hard fiber, nearly white, and finer and softer than other hard fibers as it is prepared in Mauritius, 150 to 250 cm. long, from the leaves of the giant cabuya, *Furcraea gigantea*, native in eastern Brazil and cultivated in Mauritius, India and Natal; used chiefly for mixing with other fibers to improve the color of ropes. Called "Mauritius hemp," but it is not a true hemp and is produced in other countries besides Mauritius.

Ramie.—A soft fiber, parchment-like, light yellow or greenish and stiff in the form called "China grass," white, soft and slightly coarser than flax when degummed and bleached, very strong and durable, from the inner bark of the ramie plant, *Boehmeria nivea*, cultivated in China and Japan; used in China for dress goods and "grass cloth," in Japan for seine twine and mosquito nets and in Germany for shoe thread, trimmings, tapestries, and various woven fabrics. Also called "rhea."

Sisal.—A hard fiber, of firm texture, light yellow or nearly white sometimes slightly green, very strong and durable, 100 to 180 cm. long, from the leaves of the sisal plant, *Agave sisalana*, native in Yucatan, cultivated in East Africa, Java, Sumatra, Haiti and the Bahamas; used in hard fiber twines including binder twine and also in coarse cordage.

Bahama Sisal.—Retted in sea water and cleaned by hand; is finer, softer, weaker and lacking in luster.

Fibers, Vegetable (Continued):

Sunn.—A soft fiber, gray or brown with a wide range of color and quality due to differences in preparation, 50 to 150 cm. long, from the inner bark of the sunn plant, *Crotalaria juncea*, cultivated in India; used in twines. Also called "Sunn hemp," "India hemp," "Bombay hemp," "Brown hemp," and various sorts by the names "Benares," "Itarsi," "Jubbulpore," "Madras" and "Sewnee."

Filament.—A fine fiber or fibril.

Flax.—See Fibers, Vegetable.

Float (Defect).—A place in the fabric where warp or filling threads extend unbound over threads with which they should be interlaced.

Gage.—A measure of the fineness of knit fabric as determined by the closeness of the wales, that is, the longitudinal rows of loops. It is expressed by the number of wales or needles in one and one half inches.

NOTE.—The word "gage" is also used as an expression of thickness.

Gombo Hemp.—Under Fibers, Vegetable, see Kenáf.

Grenadine Yarn (Silk).—A yarn composed of more than one strand, each individual strand of which has been doubled with a reverse twist, each twist having a minimum of approximately the following number of turns per inch depending on the number of strands used:

STRANDS	MINIMUM NUMBER OF TURNS
2 ($\frac{13}{15}$ denier or equivalent)	32
3	30
4	28

NOTE.—When more than 4 strands are used, the minimum number of turns are decreased in accordance with the above proportion.

Hairiness (Raw Silk).—The condition of the thread when there are numerous loose ends of cocoon filaments projecting from the thread.

Hawser Twist (Cotton).—A twine, cord or rope construction in which the first and second twists are in the same direction and the third twist in the opposite direction.

Heavy Corkscrews.—See Corkscrews.

Heavy Goods.—Name applied in Calcutta quotations to material called "sacking" in the United States.

Hemp.—See Fibers, Vegetable.

Henequen.—See Fibers, Vegetable.

Hessians.—Name applied in United Kingdom, India, and on the Continent to material called "burlap" in the United States.

Holland Finish (Cotton).—A glazed or unglazed finish, consisting of oil and a filling material, applied to cotton fabrics to make them opaque or semi-opaque; resembles a beetled linen fabric formerly known as "Holland."

Indian Hemp.—Under Fibers, Vegetable, see Sunn.

Istle.—See Fibers, Vegetable.

Italian Hemp.—Under Fibers, Vegetable, see Hemp.

Jackets (woven or felted).—A textile product, woven or pressed into tubular or sleeve form, ready for covering and shrinking on a machine roll.

Jubbulpore Hemp.—Under Fibers, Vegetable, see Sunn.

Jute.—See Fibers, Vegetable.

Jute Butts.—See Fibers, Vegetable.

Kapok.—See Fibers, Vegetable.

Kenăf.—See Fibers, Vegetable.

Kink (fabric).—A place in the fabric where a slack strand has twisted on itself, forming a loop in the yarn or cord.

Knot.—A joining by tying of threads together.

Long Knots (Raw Silk).—Knots which have loose ends from 3 to 25 mm. ($\frac{1}{8}$ to 1 in.) in length.

Very Long Knots (Raw Silk).—Knots which have loose ends exceeding 25 mm. (1 in.) in length.

Laid Fabric (Cotton).—A fabric made without filling yarn, the parallel warp yarns being held together by means of rubber latex or other binding material.

Lea (Cotton).—A 120-yd. skein of yarn containing 80 turns, that is, each $1\frac{1}{2}$ yd. in length.

(Linen).—See Yarn Number (Linen).

Loop-Knot.—A snarl or curl produced by a filling yarn coiling upon itself.

Loops (Raw Silk).—Small open places in the thread due to the excessive length of one or more cocoon filaments.

Long Loops.—Loops which exceed 1 cm. ($\frac{1}{2}$ in.) in length.

Long Knot.—See Knot.

Maguey.—Under Fibers, Vegetable, see Cantala and Mescal Maguey.

Manila Hemp.—Under Fibers, Vegetable, see Abacá.

Mauritius Hemp.—Under Fibers, Vegetable, see Piteira.

Mescal Maguey.—See Fibers, Vegetable.

Metallic Asbestos Yarn.—See Asbestos Yarn.

Mexican Fiber.—Under Fibers, Vegetable, see Istle.

Mexican Sisal.—Under Fibers, Vegetable, see Henequen.

Mispick.—A pick not properly interlaced.

Moisture Content (Moisture, Percentage of Moisture).—The moisture present in a textile material expressed as a percentage of the original weight as determined by definite prescribed methods.

Moisture-Free Weight.—The weight of a textile material determined after drying to constant weight by definite prescribed methods.

Moisture Regain.—The moisture present in a textile material expressed as a percentage of the moisture-free weight, as determined by definite prescribed methods.

Natal Hemp.—Under Fibers, Vegetable, see Piteira.

Neatness (Raw Silk).—An expression of the degree of freedom of the raw silk thread from loops, nibs, and hairiness as defined.

New Zealand Flax.—Under Fibers, Vegetable, see Phormium.

Nibs (Raw Silk).—Small thickened places less than 3 mm. ($\frac{1}{8}$ in.) in length.

Nitrocellulose Rayon.—See Fibers, Artificial.

Number of Yarn.—See Yarn Number.

Off-Square.—The difference between the percentage of warp crimp and the percentage of filling crimp.

Organzine Yarn.—Two or more raw silk strands twisted in the singles, doubled and twisted in the reverse direction in the ply. Turns per inch in the singles and ply usually within the limits of 10 to 20 turns; generally used as warp.

Palma.—See Fibers, Vegetable.

Philippine Maguey.—Under Fibers, Vegetable, see Cantala.

Phormium.—See Fibers, Vegetable.

Pick.—An individual filling yarn.

Piteira.—See Fibers, Vegetable.

Plain Weave.—A fabric pattern in which each yarn of the filling passes alternately over and under a yarn of warp and each yarn of the warp passes alternately over and under a yarn of the filling.

Ramie.—See Fibers, Vegetable.

Raw Silk.—Silk as it has been reeled from the cocoon.

Rayon.—A generic term for filaments made from various solutions of modified cellulose by pressing or drawing the cellulose solution through an orifice, and solidifying it in the form of a filament.

NOTE.—Rayon as commercially manufactured is produced by four different processes. The resulting rayons from each process while similar in appearance differ amongst themselves and with each other to a more or less degree according to the differences in their physical and chemical properties. The different type rayons are known as follows:

(*a*) Nitrocellulose Rayon (Chardonnet)
(*b*) Viscose Rayon
(*c*) Cuprammonium Rayon
(*d*) Cellulose-Acetate Rayon

Reed Marks.—Marks or lines warpwise of the cloth, usually caused by too many or too few warp yarns being drawn into a dent, a faulty setting of the loom, or imperfections in the reed.

Regain.—See Moisture Regain.

Reinforced Asbestos Roving.—See Asbestos Roving.

Run (Woolen).—See Yarn Number (Woolen Run).

Russian Hemp.—Under Fibers, Vegetable, see Hemp.

Sewed Yarn.—A yarn in the fabric interwoven by hand.

Shoe-Fold.—The fabric is folded from both ends into twelve or sixteen folds to the piece, the length of the fold depending upon the length of the piece.

Sisal.—See Fibers, Vegetable.

Size.—See Yarn Number.

Slub.—See Slug (General).

Slug (Raw Silk).—A thickened place several times the diameter of the thread, 3 mm. ($\frac{1}{8}$ in.) or over in length.

Long or Large Slug (Raw Silk).—A slug which exceeds 1 cm. ($\frac{1}{2}$ in.) in length or which is very much larger in diameter than the thread.

(General).—An abruptly thickened place in the yarn or a bunch of lint entangled in the yarn, cord, or fabric.

Smash.—A place in the fabric where a number of warp yarns or cords have been broken, usually due to the shuttle getting caught in the shed during weaving, or to faulty harness motion.

Spun Silk.—Silk yarn consisting of short filaments obtained from silk wastes spun in a similar manner to worsted yarn.

Standard Atmosphere (Textiles).—Air maintained at a relative humidity of 65 per cent at a temperature of 70 F.

Standard Moisture Regain.—An arbitrary figure formally adopted for the regain of any specific textile material to be used in calculating the standard weights of shipments or deliveries of textiles.

Standard Weight.—The moisture-free weight of a textile material plus the weight corresponding to its standard moisture regain.

Sunn.—See Fibers, Vegetable.

Tampico Fiber.—Under Fibers, Vegetable, see Istle.

Thick and Thin Places (Major Defects).—Places in the fabric where for 1 in. or more the count varies more than a specified percentage from the specified count.

(Minor Defects).—Places in the fabric where for less than 1 in. the count varies more than a specified percentage from the specified count.

Thread (Silk).—The ply of yarns is sometimes referred to as the number of thread, as 2 thread for a 2 ply.

Thrown Silk.—Raw silk that has been twisted, or doubled and twisted.

Tientsin Jute.—Under Fibers, Vegetable, see Chingma.

Tire Builder Fabric.—A fabric consisting of hawser cord yarn in the warp with single yarn filling at intervals to keep the warp threads together.

Tossa Jute.—Under Fibers, Vegetable, see Jute.

Tram Yarn (Silk).—Raw silk threads doubled and twisted with a low number of turns per inch, generally used as filling.

Tula Istle.—Under Fibers, Vegetable, see Istle.

Twill Weave.—A weave which produces pronounced lines running diagonally across the fabric.

Warp Face Twill.—A twill weave in which the warp threads produce the diagonal effect.

Twine (Not Binder Twine).—A cord made up of two or more yarns of medium twist with ply twist in the opposite direction.

Twist, Direction of.—In the case of yarn or cord held in a horizontal position and fixed at the left end, if the twist is taken out by turning to the right, or clockwise, when viewed from the right end, it is right twist, and, if the twist is taken out by turning to the left, or counter-clockwise, when viewed from the right end, it is left twist; that is, the yarn or cord has right twist if, when it is held vertically, the spirals or twists are seen to incline upward to the right, and has left twist if the spirals or twists are seen to incline upward to the left.

NOTE.—This definition is used by the cotton and wool industries. Due to trade custom, the opposite of this definition is used by the sewing thread, silk, and rayon industries.

Viscose Rayon.—See Fibers, Artificial.

Webbing, Elastic.—A strong narrow fabric made with rubber threads as part of warp or filling or of both.

Wrong Draw.—A defect in a fabric due to the warp and filling not interlacing in accordance with the prescribed weave or design and caused when one or more warp yarns have been drawn through the wrong harness.

Yarn.—An assemblage of fibers or filaments of animal, mineral, or vegetable origin, alone or in combination, either natural or manufactured, twisted or laid together to form a strand or group of strands for use in weaving, knitting, or forming in any manner into textile materials.

Yarn Number (Asbestos).—See Cut (Asbestos).

(Cotton).—The number of 840-yd. hanks contained in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the single yarn from which they are spun.

(Jute).—The weight in pounds of a spindle of 14,400 yd. of yarn at standard conditions expressed as "pounds per spindle."

(Linen).—The number of 300-yd. hanks contained in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the single yarn from which they are spun. Also known as "lea."

(Raw Silk).—See Denier.

(Rayon).—See Denier.

(Spun Rayon).—The number of 840-yd. hanks contained in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the single yarn from which they are spun.

(Spun Silk).—The number of 840-yd. hanks contained in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the finished yarn.

(Woolen—Cut).—The number of 300-yd. "cuts" or hanks in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions.

(Woolen—Run).—The number of 1600-yd. hanks in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions.

(Worsted).—The number of 560-yd. hanks in 1 lb. avoirdupois (7000 grains) of the yarn at standard conditions. The number of folded or plied yarns is that of the single yarn from which they are spun.

Yarn Size.—See Yarn Number.

TENTATIVE METHODS OF IMPACT TESTING OF METALLIC MATERIALS[1]

A.S.T.M. Designation: E 23 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

Issued, 1933; Revised, 1934.[2]

Scope

1. (*a*) These methods of notched-bar impact tests are intended for comparison of the brittleness of metals. The impact test consists of the determination of the energy absorbed in fracturing an arbitrarily notched specimen by a single blow of a calibrated pendulum. The tests are based on the assumption that resistance to shock depends upon the ability of materials rapidly and safely to equalize dangerously concentrated stresses by plastic flow or equivalent action. The specimen is notched to produce an intense concentration of stress as a test condition and the notch is therefore a necessary feature of the specimen unless the inherent structure of the material to be tested is such as to produce an equivalent internal condition.

(*b*) The indications of the test shall be stated only in terms of the total energy required to break a standardized specimen under standardized conditions and cannot be generalized and applied quantitatively to other sizes of test pieces or other conditions. Unless specifically supported in a particular case, the interpretation of results shall be restricted within the established limitations of the test as indicated in the Appendix.

Mechanics of the Test

2. The essentials of an impact test are (*1*) a suitably notched specimen, (*2*) a moving mass of known kinetic energy which must be great enough to cause fracture of a test specimen placed in its path, (*3*) an anvil or support on which the test specimen is placed to receive the blow of the moving mass, and (*4*) a device for measuring the residual energy in the moving mass after the specimen has been broken. Many different arrangements of these elements are possible and may yield satisfactory individual comparisons. For standardized

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee E-1 on Methods of Testing.

[2] Revision accepted by Committee E-10 on Standards, November 15, 1934.

results the essential features are the specimen and its manner of support and fracture.

3. Two methods of holding and striking the specimen are recognized as standard, (*a*) the Charpy test and (*b*) the Izod test.

(*a*) *Charpy Test.*—In the Charpy test the specimen is held as a simple beam (usually horizontal) and is broken by a single blow delivered midway between the supports.

(*b*) *Izod Test.*—In the Izod test the specimen is held as a cantilever beam (usually vertical) and is broken by a blow delivered at a fixed distance from the edge of the specimen clamp.

4. (*a*) The Charpy type test may be made on unnotched specimens if indicated by the characteristics of the material tested but the Izod type test is not suitable for other than notched specimens.

(*b*) In both types of test the specimen shall be struck so that the root of the notch is in the region of the tensile beam stress.

APPARATUS

General Requirements

5. (*a*) The machines used shall be of the pendulum type of rigid construction and of capacity sufficient to break the specimen in one blow. They shall be accurate to within 1 per cent of their calibrated capacity. The machine shall be so scaled that definitely indicated and accurate corrections may be made for friction and windage losses.

(*b*) The dimensions of the machine shall be such that the center of percussion of the striker, as defined under Sections 23 and 24, is at or only slightly above the point of impact, that is, the center of the striking edge.

(*c*) The pendulum shall be released from such a position that the linear velocity of the center of the striking edge at the instant of impact shall be at least 11 ft. per second, which is that corresponding to an initial elevation of the center of the striking edge of 2 ft. As velocity effects appear to be present in some materials and differ with the material, it may be necessary in arbitration tests to agree upon a particular velocity.

(*d*) Means shall be provided for determining the impact strength. The impact strength shall be taken as the energy absorbed in breaking the specimen and is equal to the difference between the energy in the pendulum blow at the instant of impact with the specimen and the energy remaining in the pendulum after breaking the specimen.

NOTE.—An impact machine will be inaccurate to the extent that any energy used in deformation or movement of its component parts will be registered as used in fracturing the specimen. A machine faulty in this respect will yield readings higher than the true value. The machine should, therefore, be substantially and rigidly constructed with no looseness or play in any part.

Simple Beam Apparatus (Charpy Type Test)

6. (*a*) Means shall be provided to support the test specimen against two rigidly mounted blocks in such a position that its center of gravity shall be on a tangent to the arc of travel of the striking point of the pendulum drawn at the position of impact.

(*b*) The points of support shall be 1.575 in. (40 mm.) apart. The edges of the supports shall be rounded to a radius of $\frac{1}{64}$ in. The space through which the breaking specimen is forced shall not decrease in width back of the supports and preferably should increase.

(*c*) Means shall be provided on the machine or by use of a separate gage for accurately locating the specimen so that the center line of the notch is midway between the supports.

(*d*) The center line of the striking edge shall swing in a plane midway between the supporting edges of the specimen anvils. It shall be so curved and aligned as to make contact at the center of the width of the specimen.

Cantilever Beam Apparatus (Izod Type Test)

7. (*a*) Means shall be provided for clamping the specimen rigidly in such position that the face of the specimen to be struck lies in the plane established by the striking edge in the impact position and the center of rotation. The edges of the supporting surfaces shall be sharp 90-deg. angles, and shall be in a plane 0.866 in. ± 0.005 in. (22 mm. ± 0.127 mm.) vertically below the point of impact on the striking edge in the striking position and parallel to the tangent to its arc of rotation. The clamping surfaces shall be smooth and exactly parallel so as to clamp the specimen firmly up to the notch.

(*b*) The striking edge shall be an edge formed in the position of impact by the intersection of a plane inclined at an angle of 5 deg. away from the face of the specimen and another plane perpendicular to the specimen. It shall be rounded to a radius of $\frac{1}{16}$ in. and shall be so aligned as to make contact across the full face of the specimen.

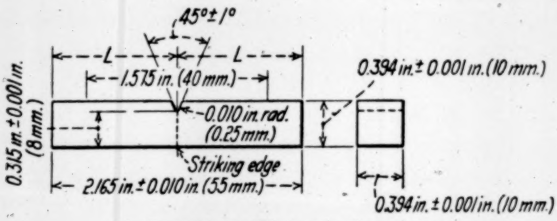
TEST SPECIMENS

Test Specimens

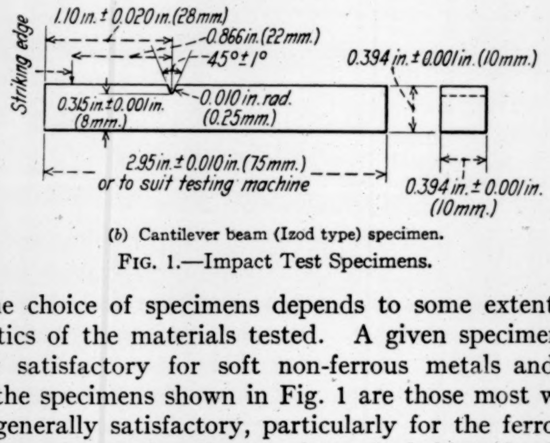
8. (*a*) All test specimens shall be finished to the final outside dimensions shown in Fig. 1 (*a*) and (*b*) by grinding or other processes resulting in an equivalent smoothness of finish. Final machining

marks shall be in the longitudinal direction, at least in the vicinity of the notch. The notch shall be cut with a special formed milling cutter provided solely for the purpose or in the case of very hard materials by grinding.

(*b*) If specimens are stamped for identification, such stamping shall be on the ends of specimens so as not to affect the clamping or support of the specimen. All stamping shall be done prior to notching to avoid cold deforming of the metal at the root of the notch.


45°±1°
L
L
1.575 in. (40 mm.)
0.394 in.± 0.001 in. (10 mm.)
0.315 in.±0.001 in. (8 mm.)
0.010 in. rad. (0.25 mm.)
Striking edge
2.165 in.±0.010 in. (55 mm.)
0.394 in.± 0.001 in. (10 mm.)

(*a*) Simple beam (Charpy type) specimen.


1.10 in. ± 0.020 in. (28 mm.)
0.866 in. (22 mm.)
45°±1°
0.394 in.± 0.001 in. (10 mm.)
Striking edge
0.315 in.±0.001 in. (8 mm.)
0.010 in. rad. (0.25 mm.)
2.95 in.± 0.010 in. (75 mm.) or to suit testing machine
0.394 in.± 0.001 in. (10 mm.)

(*b*) Cantilever beam (Izod type) specimen.

FIG. 1.—Impact Test Specimens.

(*c*) The choice of specimens depends to some extent upon the characteristics of the materials tested. A given specimen may not be equally satisfactory for soft non-ferrous metals and hardened steels but the specimens shown in Fig. 1 are those most widely used and most generally satisfactory, particularly for the ferrous metals. Accuracy of results requires that specimens be held to the dimensional tolerances shown in Fig. 1. These specimens are not considered suitable for tests of cast iron.[1]

PROCEDURE

General Precautions

9. (*a*) Before a specimen is placed in position to be tested the machine shall be put in proper adjustment to avoid excessive friction in the pendulum bearings or drag of the recording devices. The method of adjustment will depend upon the design of the machine, but a properly adjusted machine of 120-ft-lb. capacity should not

---

[1] Reference should be made to the 1933 Report of Subcommittee XV on Impact Testing, of Committee A-3 on Cast Iron, see *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 87 (1933).

lose more than 0.5 ft-lb. of energy while swinging back as far as it will go toward the initial position and then returning again to the final position, that is, in making an additional complete oscillation after a free swing.

(*b*) The friction of the recording devices shall be the minimum that will prevent over-carrying of the indicator or dropping back with the pendulum.

(*c*) The mechanism for releasing the pendulum from its initial position shall operate freely and permit release of the pendulum in a free start without initial impulse, retardation or side vibration.

Temperature of Testing

10. In some materials impact strength varies widely with temperature. Unless otherwise specified, tests should be made at 70 F. (21 C.). For specific results at temperatures other than room temperature care must be taken to maintain the specimen at the required temperature up to the moment of impact.

Friction Correction

11. The energy lost in friction and windage of the pendulum and in friction in the recording mechanism, if not corrected for, will be included in the energy loss attributed to breaking the specimen and therefore result in erroneously high values of impact strength. The total value of these losses on a full swing of the pendulum may be determined by operating the machine as in a test but without a specimen. The distribution of these losses may be determined by the methods of calibration described in Sections 15 to 26. Detailed correction need not be made unless differences are indicated which are of significant magnitude relative to the value of impact strength determined and the capacity of the machine.

Location of Test Specimen

12. It is essential that the test specimens be placed in proper position in the machine (Section 13 (*b*) and (*c*)) and that the dimensional relations of notch, supports and striking edge be fixed by the use of gages made with the greatest precision obtainable in tool room practice. A detectable error in notch position relative to the parts of the machine involved may be considered a probable cause of inaccurate results.

Operation of Machine

13. (*a*) With the specimen properly located in the machine the indicator shall be set at the initial position and the pendulum smoothly released from its initial position.

(*b*) *Simple Beam Method.*—The Charpy type test specimen shall be struck on the side opposite the notch while supported against the supporting blocks in such a position that the center line of the striking edge strikes exactly in line with the center line of the notch which shall be midway between the points of support.

(*c*) *Cantilever Beam Method.*—The Izod type test specimen shall be struck on the notched face at a point 0.866 in. ± 0.005 in. (22 mm. ± 0.127 mm.) from the center line of the notch while gripped in such position in the support vise that the center line of the notch is exactly in line with the line of support over which the specimen will be bent during fracturing.

(*d*) If any specimen fails to break, the blow shall not be repeated but the fact shall be recorded indicating whether the failure to break occurred through extreme ductility or lack of sufficient energy in the blow. Such results cannot be averaged.

Report of Test

14. The report of the test shall include the following:

(*a*) Whether simple beam or cantilever beam method was used;
(*b*) Whether the specimen used was notched or unnotched;
(*c*) The initial energy of the blow;
(*d*) The energy actually absorbed by the specimen in breaking, reported in total foot pounds;
(*e*) The number of specimens failing to break (Section 13 (*d*));
(*f*) The calculated velocity of the hammer at the instant of striking based on the initial height of the striking edge as given under Section 25; and
(*g*) The temperature of the specimen or of the room conditions if both are the same.

CALIBRATION

General Considerations

15. (*a*) Impact strength, as defined in Section 5 (*d*), is equal to the difference between the energy in the pendulum before and after impact.

(*b*) The energy of the pendulum both immediately before and immediately after breaking the specimen is kinetic energy and its value depends upon the mass of the pendulum and its rotational velocity. The difference in energy which it is desired to determine is represented by a decrease in rotational velocity.

Theoretic Basis of Calibration

16. The determination of energy values experimentally from the respective velocities would be extremely difficult but a simpler

basis of calibration is available. Neglecting losses, the kinetic energy of the pendulum at the instant of impact results from and is equal to the potential energy possessed by the pendulum at its initial elevation. Similarly, and again neglecting losses, the kinetic energy of the pendulum immediately after breaking the specimen results in and is equal to the potential energy acquired by the pendulum at the maximum elevation to which it swings after breaking the specimen. The energy absorbed by the specimen, or the impact strength, neglecting friction, vibrational or other losses, is therefore the difference in the energy of elevation of the pendulum in its initial position and in the position it attains after breaking the specimen. The calibration of a pendulum type machine may therefore be based upon the total weight of the pendulum and the elevation of the center of gravity above its lowest position. The product of the total weight in pounds and the elevation in feet gives the energy in foot pounds.

17. The location of the center of gravity may readily be determined by well-known methods. The center of gravity is, however, a theoretical point in the interior of the pendulum and in some designs it may be a point in space. The practical difficulties of measurement to this physically indefinite point may be avoided and the energy, that is, the product of the total weight and the elevation of the center of gravity may be determined experimentally without determining either value separately. The procedure is based upon the following considerations:

(*a*) Correct design requires that the striking edge be so located in the pendulum as to lie on the extension of a line drawn through the center of rotation and the center of gravity. Consider such a pendulum of total weight W and with its center of gravity at a distance R_g from the center of rotation. When moved from the position of rest through an angle α, the center of gravity rises a distance H_g. Then:

$$H_g = R_g - R_g \cos \alpha \quad \text{or} \quad H_g = R_g (1 - \cos \alpha)$$

The potential energy at this position will be:

$$E = WR_g (1 - \cos \alpha)$$

(*b*) If now the pendulum is considered supported in this position by a vertical force W' applied at any other point on the line through the center of rotation and the center of gravity at a distance R' from the center of rotation, equilibrium requires equality of moments or:

$$WR_g = W' R'$$

and therefore

$$E = W'R' (1 - \cos \alpha)$$

(*c*) Since the term $R'(1-\cos\alpha)$ represents the change of elevation of the particular point of application chosen for this new vertical force, it is possible to base the calibration upon the changes in elevation of any arbitrarily chosen point on the pendulum provided the corresponding value of reaction force or weight is used. Since the center of the striking edge is the most definitely located point on the pendulum experimental calibration should be based upon it.

EXPERIMENTAL PROCEDURE

Striking Edge Adjustment

18. The machine shall be placed exactly level and the pendulum allowed to come to rest hanging unrestrained in its bottom position. The striking edge should then coincide with a vertical line through the center of rotation. Should any measurable divergence be observed the position of the striking edge in the head of the pendulum shall be corrected by appropriate measures. In the case of machines having replaceable striking edges this is readily accomplished by removing metal or adding shims at the back of the striking edge or by complete replacement of the striking edge.

Calibration Weight of Pendulum

19. (*a*) The pendulum, complete with all moving parts, shall be supported in a horizontal position with two supports; one at the bearings (or center of rotation) and the other at the center of the striking edge. The support at the striking edge shall be arranged to react upon some suitable weighing device such as a platform scale or balance and the weight accurately determined. Care shall be taken to avoid excessive friction at either point of support. Contact should be made with the striking edge through a round rod crossing the edge at a 90-deg. angle.

(*b*) The final weight shall be determined by averaging the weight at which the pendulum begins to move upward and that at which it begins to move downward, proper allowance being made for weight of supports, etc.

(*c*) The required sensitivity of the weighing device and the accuracy of the determination will depend upon the capacity of the machine and may be calculated from the fact that the weight determined enters as a first power factor in the energy values.

Initial Energy of Blow

20. (*a*) The changes in elevation of the center of the striking edge may be determined by direct measurement from a fixed level on the machine by means of suitable height gages. If available, a cathetometer will be found useful for this purpose.

(*b*) The initial energy of blow in foot pounds will be the product of the calibration weight (as determined in Section 19) in pounds and the change in elevation of the center of the striking edge in feet when the pendulum is raised to the initial position for a test.

Scale Readings

21. (*a*) The pendulum shall be moved by hand through the striking position with the indicator mechanism operating as in a test. With the indicator at various readings on the scale, the pendulum shall be supported and the height of the center of the striking edge above the impact position shall be measured. The height in feet multiplied by the calibrated weight, in pounds, gives the residual energy of the pendulum when actually in this position.

(*b*) When the residual energy is subtracted from the energy at the instant of impact the result is the correct impact strength that should be indicated on the scale, at that position, neglecting friction corrections.

Friction and Windage Correction

22. (*a*) Precise friction correction requires that the correction represent the value of friction actually affecting the particular test considered. The total losses of a free swing without specimen are not present in an actual test in which the motions of pendulum and recorder are over smaller ranges. Proper proportionate corrections shall always be made unless the difference is not significant in terms of the required accuracy of the test.

(*b*) When the operation of the recorder is not over the full swing of the pendulum and it is necessary to determine the losses of recorder and pendulum separately for accurate friction and windage loss correction this may be done as follows:

(*1*) Operate the machine in the standard manner, but without a specimen. The value of energy absorbed thus indicated is the total loss in pendulum and indicator combined.

(*2*) Repeatedly release the pendulum from the initial position without resetting the indicator. The energy loss finally shown is that due to the pendulum alone.

(*3*) The loss of the indicator alone is then approximately the difference between the values obtained as described in (*1*) and (*2*) above.

(*c*) The two values obtained in Paragraph (*b*) may with sufficient accuracy be assumed to be distributed uniformly over their respective full ranges of action. The net correction for each test will, therefore, be that portion of the total represented by the ratio of the actual range of action in the test to the full range of action of the two retarding forces in the swings without specimen.

Center of Percussion

23. The principles of correct design indicate that energy losses in deformation and vibration are reduced if the dimensions of the pendulum are such that the blow is delivered in such relation to the distributed mass that no force is transmitted to the point of rotation. The point of impact for which this condition obtains is the center of percussion which may practically be defined as the point in a rotating body at which the dynamic mass may be considered concentrated. The center of percussion is located at a distance from the center of rotation equal to the length of a simple pendulum of the same period.

Determination of Center of Percussion

24. (*a*) The location of the center of percussion may be determined experimentally in an actual machine from the expression:

$$l = 0.81\ P^2$$

where l = the distance from the axis to the center of percussion, and
P = the time in seconds of a complete swing (to and fro).

(*b*) In determining P the pendulum shall be allowed to swing only through a small angle not over 10 to 15 deg. The time for a considerable number of swings shall be determined and the average value calculated.

NOTE.—A machine of strong construction may give satisfactory results with a considerable variation from the correct condition but in general it is considered desirable that the center of percussion be as close as possible to the striking edge. The center of percussion may be lowered or raised by the addition of weight below or above the striking edge, respectively. Such changes require considerable care and will change the capacity and calibration of the machine. They should not be made unnecessarily or without careful study.

Striking Velocity

25. The determination of the striking velocity of the machine, neglecting friction, may be made by means of the following expression which is derived from the general laws of motion applying to rigid, rotating bodies:

$$V = \sqrt{2\ gh}$$

where V = the striking velocity in feet per second;
g = the acceleration of gravity in feet per second per sound; and
h = the initial elevation of the center of percussion in feet (or with sufficient accuracy in most machines, the elevation of the center of the striking edge).

INSPECTION AND PRECAUTIONS

General Inspection and Precautions

26. Calibration also will require check and adjustment, if necessary, of the various mechanical dimensions specified in the particular method of test and other general precautions such as the following:

(*a*) With the striking edge in line with the center of gravity and the center of rotation as described in Sections 17 and 18, the striking edge should just touch the specimen when the pendulum is hanging at the position of rest and the machine is level. Any corrections necessary shall be made in the position of the specimen or in the position of the bearing supports for the pendulum.

(*b*) The specimen shall be so supported that at the instant of impact the striking edge strikes flat and across the face of the specimen in the Izod type test and at the center point of the specimen in the Charpy test.

(*c*) The release mechanism shall not bind or exert any accelerating, retarding or vibrational forces during the initial motion of the pendulum.

(*d*) In machines equipped with brakes to prevent free return of the pendulum after breaking a specimen, free swings shall be made with the brake device both inoperative and operative and the effect, if any, observed on the reading. Any significant difference in reading shall be eliminated.

(*e*) Careful measurements shall be made to establish agreement with the dimensional requirements of Sections 6 and 7.

APPENDIX

A1. *Applications of the Impact Test.*—The basic assumption of the impact test is that resistance to shock depends upon the ability of material rapidly and safely to equalize concentrated stresses.

A2. It is an essential feature of the test that the initial stress be highly localized by the notch and by the rapidity of the blow. Unavoidably, therefore, the intensity and distribution of stress during the break do not yield to analysis in terms of the dimensions of the test piece and method of load application as they depend upon the characteristics of the particular material. The results, therefore, are stated only in terms of the total energy required to break a standard specimen under established conditions. Interpretation of results must be based upon specific research or upon the established limitations of the test.

A3. *Relation to Service Conditions.*—A large part of the total energy indicated as impact strength is expended in deforming the material tested beyond the elastic limit and causing complete fracture. The comparison of materials by this test is, therefore, based to a large extent upon this part of their properties. Such a comparison would have little meaning in parts so carefully designed or so fortunately situated as never to be stressed above the elastic limit at any point.

A4. In present engineering practice there are many parts which by reason of their functioning must be of intricate shape with drastic changes in cross section. When such parts are subject to sudden or impact loading, concentrated stresses of high and generally unpredictable magnitude occur in the region of the change of section. It is to materials for such uses that the impact test applies and the indications of the test are well established as a criterion of satisfactory service use in a large number of specific applications.

A5. Correlation between service failure and low impact strength values for heat-treated forgings has been definitely established in a considerable number of critical uses. The formal specification of impact strength limits based on experience is established practice of representative manufacturers in the following instances:

(*a*) Aviation engine parts such as connecting rods, pins, gears, cylinder retaining loops;
(*b*) Crankshafts for important uses such as aviation engines, industrial engines, truck and tractor engines;
(*c*) Alloy-steel forgings for gun parts, propeller shafts, live axles, etc.;
(*d*) Clash gears for automotive transmissions, particularly for heavy duty uses such as trucks and tractors;
(*e*) Turbine blading;
(*f*) Links, pins, etc., for tractor belts;
(*g*) Wood parts for airplane construction; and
(*h*) Molded parts for telephone apparatus.

A6. *Comparison of Materials.*—The indications of the impact test are more significant in the comparison of generally similar materials such as different classes of steel or steel from different sources than in the comparison of materials of widely different types such as soft copper and hardened steel. It is most significant as an indication of the effect of different variations or treatments of the same material, such as cold working or heat treatment.

A7. In heat treatment of steel (particularly alloy steels such as chrome-nickel) it gives comparisons of temper brittleness not shown by static tests and is invaluable in developing the best heat treatment for a particular steel.

A8. The indications of the impact test can be applied to the development and control of steel through its original production to the development of particular properties after a given heat treatment.

A9. The impact is of great value in the detection and control of abuses in the forge shop such as excessive temperatures and improper response to heat treatment.

A10. Similarly, the detection of deficiencies in process by this type of test are established in the case of materials such as porcelain and crockery and in organic molded materials.

TENTATIVE METHOD OF TEST

FOR

SHORT-TIME HIGH-TEMPERATURE TENSION TESTS OF METALLIC MATERIALS[1]

A.S.T.M. Designation: E 21 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1933; REVISED, 1934.[2]

Scope

1. This method covers short-time high-temperature tension tests of metals within the range from room temperature to 2000 F. In the interests of coordination of data, it is recommended that the tests be made, as far as possible, at the following temperatures: 70, 300, 500, 750, 900, 1000, 1100, 1200, 1400, 1600, 1800 and 2000 F. It is recognized that for special purposes, tests at other temperatures may be desirable.

Selection of Metals for Test

2. This method presupposes agreement upon the selection of suitable samples for test specimens to meet the requirements of individual applications.

NOTE.—In the testing of some materials it is customary and often necessary to subject the specimens to a stabilizing treatment. If such is done, it shall be reported fully in the recorded data.

Test Specimens

3. The tension test specimen shall be of the usual type for 2-in. gage length, see Fig. 1, as described in Section 15 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[3] The diameter of the test specimen shall be 0.505 in. ± 0.001 in. The diameter of the reduced section of the specimen between base of fillets shall not vary by more than ±0.0005 in. The surface shall be machined smooth and free from tool marks or scratches. It shall be finished by

---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the Joint A.S.M.E. - A.S.T.M. Research Committee on Effect of Temperature on the Properties of Metals.

Cooperation was given by Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys of the American Society for Testing Materials in the preparation of this tentative method of test.

[2] Revision accepted by Committee E-10 on Standards, August 22, 1934.

[3] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

polishing with No. 00 emery cloth. The ends of the test specimen shall be threaded, shall be at least $\frac{3}{4}$ in. in diameter, and shall be machined true and axial. They shall be gripped in the testing machine in such manner that the load shall be axially applied.

Testing Apparatus

4. (*a*) *Testing Machine.*—The type of testing machine to be used in short-time high-temperature tension tests is not specified, but shall be reported with the results of a series of tests. The accuracy of the testing machine shall be within the tolerances specified in the Tentative Methods of Verification of Testing Machines (A.S.T.M. Designation: E 4 - 34 T) of the American Society for Testing Materials.[1]

(*b*) Precautions shall be taken to insure that the testing load is axially applied. Each specimen when set up for test shall be inspected for faulty alignment in the machine. Eccentricity of loading can often be detected by elastic extension measurements taken at room temperature before commencing the test. Apparatus provided with extensometers affording measurements on opposite sides will reveal unsatisfactory alignment when unequal strain is shown by the opposite readings. Elongation measuring devices which show extension on one side of the specimen only do not readily lend themselves to the detection of eccentric loading.

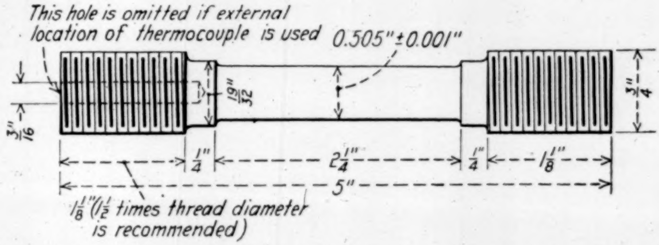

This hole is omitted if external location of thermocouple is used
0.505"±0.001"
3/16"
19/32"
3/4"
1/4"
2 1/4"
1/4"
1 1/8"
5"
1 1/8" (1 1/2 times thread diameter is recommended)

FIG. 1.—Test Specimen for High-Temperature Tension Tests.

(*c*) *Shackles.*—The type of shackles used to obtain axial loading is not specified, but a detailed description of the shackles used shall be reported with the results of a series of tests.

NOTE.—It is to be noted that eccentricity of loading of the specimen may be lessened by using rods or wire cables of the greatest length possible to connect the shackles to the heads of the testing machine.

Furnace and Heating

5. (*a*) A drawing showing the furnace and heating element in detail shall be submitted with the results of a series of tests.

---

[1] See p. 1233.

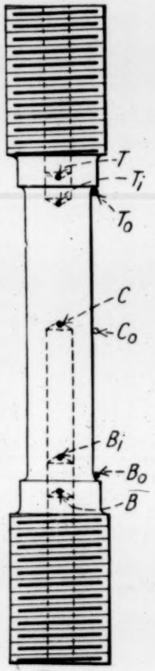


FIG. 2.

Location of Thermocouples

T Inside top end beyond fillet
T_i Inside top end at or within fillet
T_o Outside top end at fillet
C Inside at center of length
C_o Outside at center of length
B Inside bottom end beyond fillet
B_i Inside bottom end at or within fillet
B_o Outside bottom end at fillet

	Nominal Test Temperature, deg. Fahr.									
T										
T_i										
T_o										
C										
C_o										
B										
B_i										
B_o										

FORM I.—Form for Reporting Temperature Survey of Furnace.

The above form on letter size sheets suitable for recording test data is available in pads of 25 sheets at 50 cents per pad; 3 pads, $1.00. Address, American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

(*b*) The design of the furnace shall be such that the maximum variation of temperature over the gage length of the calibration bar, shown in Fig. 2 (see Form I), will not exceed 10 F. for temperatures up to and including 1600 F. and will not exceed 20 F. for higher temperatures.

NOTE.—It should be noted that the transverse dimensions of the furnace should be as small as possible, merely large enough to allow for the shackles and extensometer. Any suitable arrangement of the heating element that will result in the required uniformity of temperature is considered satisfactory. It may be noted that equalization of temperature over the length of the test specimen may be improved by a metallic lining inside the furnace tube, or by the use of multiple heating coils. Liquid baths may be used at lower temperatures provided that no reaction of the liquid upon the test metal occurs. Oil is suitable at lower temperatures. No definite recommendations are made as to the length of the furnace, provided the required uniformity of temperature is realized. Reference to the various publications of the Joint Research Committee is suggested for guidance.

Temperature Measuring Apparatus

6. (*a*) Temperature measurements shall be made by means of suitable thermocouples and potentiometer or millivoltmeter equipment, which shall be accurate to within the following permissible variations for the temperature ranges shown:

	PERMISSIBLE VARIATIONS
Up to and including 1200 F.	± 3 F.
Over 1200 to and including 1600 F.	± 5 F.
Over 1600 F.	± 10 F.

(*b*) The hot junction of the thermocouple shall be located at any one of locations T, T_o, C_o, B_o, B shown in Fig. 2, and the location of the junction shall be reported with the results of tests. Where external contact is made between thermocouple bead and the specimen, the thermocouple shall be shielded in like manner in the tension tests and in the calibration.

Temperature Survey of Furnace

7. (*a*) A survey of the temperature distribution throughout the test specimens shall be made before making a series of tests of specimens of a given metal, on each furnace and test shackle arrangement used. This survey shall be made using a special calibration bar, shown in Fig. 2 (Form I), and for each series of tests the calibration bar used shall be of the same dimensions and shall be of the same type chemical composition as the test specimens to be used. A survey of temperature distribution shall be made for each temperature at which specimens shall be tested, and detailed results of these surveys are to be reported with the results of specimen tests. These surveys

furnish data for the comparison of specimen temperature at the point where the thermocouple is applied in routine tests of specimens with the temperature of the test specimen at the middle of the reduced section of the test specimen on the axis of the specimen (*C*, Fig. 2). The temperature of the calibration bar shall be also determined at the other points indicated in Fig. 2.

(*b*) During a survey of temperature distribution on a calibration, all temperature readings shall be taken as nearly simultaneously as possible.

Room Temperature During Test

8. During the period of time required for survey tests and tests of specimens of a metal the range of room temperature shall not exceed 10 F. During all tests the equipment shall be shielded from abnormal drafts.

Temperature Equilibrium

9. Both in survey tests and tests of specimens to fracture great care shall be taken, after heating to the desired temperature, to be assured that thermal equilibrium has been reached before temperatures are recorded or load and strain readings are taken. In no case shall this heating period be less than 1 hr. The current used in heating the specimen up to the desired temperature shall be approximately that required to hold it at that temperature.

Strain Measurement During Test

10. There shall be reported with the results of all tests, the construction details of the extensometer used, the method of attaching it, and any optical methods for taking strain measurements. The extensometer shall read directly to 0.0002 in. or less for a 2-in. specimen. Whenever feasible, the extensometer should be attached to the gage length of the test specimen, but it is permissible to attach the extensometer to the ends of the shackles projecting beyond the furnace. It is also permissible to employ suitable optical methods of measurement.

NOTE.—Extensometers attached to the rods or shackles beyond the furnace apparently give satisfactory results as to yield strength; but in the determination of elastic modulus, the extension should be taken over a definite portion of the gage length.

Test Procedure

11. (*a*) After thermal equilibrium has been established at the temperature desired for the test of a specimen, a series of load and extensometer readings shall be taken under increasing load until the yield strength has been passed.

(*b*) During the part of the test in which the extensometer is in place the speed of head of the testing machine shall in no case exceed 0.1 in. per minute, and, during the period when readings of load and stretch are being taken, the head of the testing machine shall be stopped or its speed so reduced that simultaneous load and extensometer readings may be taken accurately. Within the range of stretch up to the yield strength, at least ten increments of load (or stretch) shall be taken, and as many more as may be necessary to obtain sufficient data for plotting the points for a good stress-strain diagram. If possible, the speed of head should be so regulated as to require about 10 seconds to apply an increment of load (or stretch). If it is found necessary to stop the motion of the head of the testing machine while taking load and extensometer readings, such readings shall be taken as rapidly as is consistent with accuracy. The time consumed in taking the readings shall be reported with the results.

(*c*) After the yield strength has been passed, the extensometer shall be removed and the test continued to rupture, noting the maximum load carried by the specimen. The speed of the head of the testing machine during this period shall be at a rate of not less than 0.22 nor more than 0.28 in. per minute. After the specimen has ruptured, the elongation in the 2-in. gage length and the reduced diameter at rupture shall be measured as described in Sections 29 and 30 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1] The location and description of the fracture shall be noted.

Calculation of Stress and Strain

12. For any given test load the stress shall be determined by dividing the maximum load by the area of original cross-section of the test specimen. The strain shall be determined by dividing the elongation in the gage length by the original gage length of the specimen.

Recording and Reporting Data

13. A uniform system of recording and reporting of data shall be used. The accompanying forms for recording and reporting shall be used so that results from cooperating laboratories may be readily compared.

(*a*) *Reporting Temperature Surveys.*—For reporting the results of the temperature distribution surveys, Form I is recommended.

(*b*) *Stress-Strain Diagrams.*—Stress-strain diagrams of all tests of specimens shall be included in the report. For plotting stress-strain diagrams[1] of tests the following scales are recommended:

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

YIELD STRENGTH VALUES, LB. PER SQ. IN.	SCALE FOR STRESS (ORDINATES)	SCALE FOR STRAIN (ABSCISSAS)
70 000 to 140 000	1 in. = 20 000 lb. per sq. in.	1 in. = 0.002 in. per in.
35 000 to 70 000	1 in. = 10 000 lb. per sq. in.	1 in. = 0.001 in. per in.
Below 35 000	1 in. = 5 000 lb. per sq. in.	1 in. = 0.0005 in. per in.

FORM II.—FORM FOR REPORTING DATA AND RESULTS OF SHORT-TIME HIGH-TEMPERATURE TENSION TESTS.[a]

Material.. From..

Testing Machine.. Extensometer..

Date.. Test Laboratory..

1. RESULTS OF TEMPERATURE DISTRIBUTION SURVEY

Specimen						
Nominal test temperature, deg. Fahr.						
Inside temperature, end of specimen beyond fillet, deg. Fahr.						
Inside temperature center of length of specimen, deg. Fahr.						

2. OBSERVED DATA OF SHORT-TIME HIGH-TEMPERATURE TENSION TESTS

Speed of head of testing machine up to removal of extensometer, in. per minute						
Speed of head of testing machine after removal of extensometer, in. per minute						
Original diameter of specimen, in.						
Reduced diameter of specimen, in.						
Maximum load, lb.						
Elongation in 2 in., in.						
Type of fracture						
Location of fracture						

3. CALCULATED RESULTS OF SHORT-TIME HIGH-TEMPERATURE TENSION TESTS

Tensile strength, lb. per sq. in.						
Yield strength (0.2 per cent of set), lb. per sq. in.						
Elongation in 2 in., per cent						
Reduction of area, per cent						

[a] The above form on letter size sheets suitable for recording test data is available in pads of 25 sheets at 50 cents per pad; 3 pads, $1.00. Address, American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

The *yield strength* for each specimen tested shall be determined from its stress-strain diagram. Yield strength is defined as the stress at which a material exhibits a specified limiting permanent set. For short-time high-temperature tension tests of iron, steel and the stronger non-ferrous metals the specified limiting permanent set shall be taken as 0.2 per cent of the gage length of the specimen, and the "set method" of determining yield strength, as described in Section 26 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials[1] shall be used.

---

[1] Dietzgen No. 340–10 or equivalent cross-section paper is recommended for this purpose.

(*c*) *Reporting Test Data.*—For reporting the data and results of short-time high-temperature tension tests Form II is recommended.

(*d*) *Plotting Test Data.*—For showing the general results of a series of short-time high-temperature tension tests a set of graphs[2] is recommended, in which temperature values are plotted as abscissas and values of (*1*) tensile strength, (*2*) yield strength, (*3*) elongation in 2 in., and (*4*) reduction of area are plotted as ordinates. For steel and the stronger non-ferrous metals the following scales for plotting are recommended:

		Tension Test Scale (Ordinates)	Temperature Scale (Abscissas)
Tensile strength and Yield strength	Max. tensile strength not over 100,000 lb. per sq. in..........	1 in. = 10,000 lb. per sq. in.	1 in. = 200 F.
	Max. tensile strength over 100,000 lb. per sq. in.............	1 in. = 20,000 lb. per sq. in.	1 in. = 200F..
Elongation and Reduction of area	....	1 in. = 10 per cent	1 in. = 200 F.

(*e*) *Summary of Data.*—In reporting results of short-time high-temperature tension tests full information about material, apparatus and test methods shall be reported, as follows:

Materials.—The report shall include the following information concerning the materials tested:

Process of manufacture and whether material is rolled, forged or cast.

Complete chemical analysis.

Complete details of heat treatment.

Physical properties of the material at room temperature.

Size of sample from which specimens were cut.

Relative location and direction of specimen. (Illustrate with sketch.)

If material was removed from service, complete details of service conditions shall be given.

Microstructure and deep etch of samples.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

[2] Dietzgen No. 340–10 or equivalent cross-section paper is recommended for this purpose.

Test Methods.—The report shall include the following information concerning the apparatus and methods of testing:

Description of apparatus, shackles used, method of calibrating loading mechanism and accuracy of loading.

Description of temperature control-recording arrangement.

Description of furnace.

Description of elongation measuring device.

Radical departures, if any, from recommended procedure and technique.

Results of temperature surveys of furnace, Form I (see Paragraph (*a*)).

Stress-strain diagrams (see Paragraph (*b*)).

Test data required on Form II (see Paragraph (*c*)).

Curves showing relation of physical properties to temperatures (see Paragraph (*d*)).

TENTATIVE METHOD OF TEST
FOR
LONG-TIME (CREEP) HIGH-TEMPERATURE TENSION TESTS OF METALLIC MATERIALS[1]

A.S.T.M. Designation: E 22 – 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1933; REVISED, 1934.[2]

Scope

1. (*a*) This method covers long-time (creep) high-temperature tension tests of metals within the range from room temperature to 2000 F.

(*b*) Long-time tension tests are made at those elevated temperatures where creep effects assume technical or engineering importance. The ranges of temperature usually investigated are as follows:

	TEMPERATURE RANGE, DEG. FAHR.
Carbon steels	550 to 1100
Low alloy steels (less than 8 per cent alloy content)	550 to 1200
High alloy steels (non-austenitic)	750 to 1400
High alloy steels (austenitic[a] and semi-austenitic)	750 to 1800
Nickel-chromium and high nickel-chromium-iron alloys	900 to 2000
Copper and aluminum alloys	200 to 800

[a] Under austenitic alloys are included those alloys wholly austenitic, austenitic-ferritic, and those which may change from originally an austenitic structure to some other conditions not definitely known.

(*c*) Testing temperatures shall be established at points that are multiples of 50 on the Fahrenheit scale, or equivalents on the Centigrade scale. It is recognized that for special purposes, tests at other temperatures may be desirable to establish the creep characteristics.

Selection of Metals for Test

2. This method presupposes agreement upon the selection of suitable samples for test specimens to meet the requirements of individual applications.

NOTE.—In the testing of some materials it is customary and often necessary to subject the specimens to a stabilizing treatment. If such is done, it shall be reported fully in the recorded data.

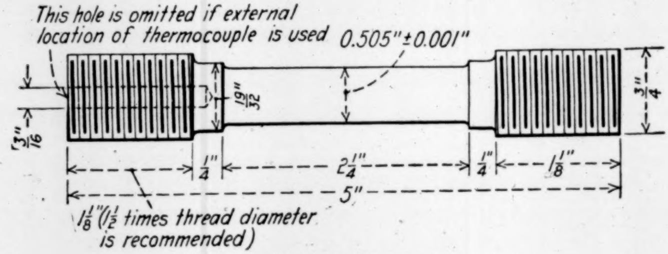
---

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the Joint A.S.M.E. - A.S.T.M. Research Committee on Effect of Temperature on the Properties of Metals.

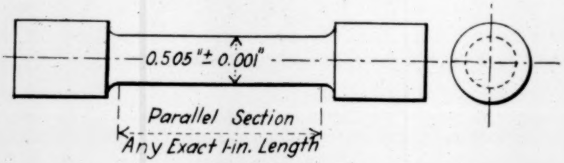
[2] Revision accepted by Committee E-10 on Standards, August 22, 1934.

Test Specimens

3. (*a*) Test specimens may be of either of the types shown in Fig. 1 (*a*) or (*b*). The diameter of the test specimen shall preferably be 0.505 in. ± 0.001 in. In cases where small diameter is imperative, specimens having a diameter of 0.357 in. or 0.252 in. may be used, but the gage length shall be not less than 2 in. The diameter of the reduced section of the specimen between base of fillets shall not vary by more than ±0.0005 in. The surface shall be machined smooth and free from tool marks or scratches, and finished with No. 00 emery cloth.


This hole is omitted if external location of thermocouple is used
0.505"±0.001"
19/32"
3/4"
3/16"
1/4"
2 1/4"
1/4"
1 1/8"
5"
1 1/8" (1 1/2 times thread diameter is recommended)

(*a*) Specimen with threaded ends.


0.505"± 0.001"
Parallel Section
Any Exact 1-in. Length

(*b*) Specimen with blank ends.

FIG. 1.—Test Specimens for High-Temperature Tension Tests.

(*b*) In the case of Fig. 1 (*a*), the ends of the specimen shall be threaded, at least ¾ in. in diameter for the 0.505-in. specimen, ½ in. in diameter for the 0.357-in. specimen, and ⅜ in. in diameter for the 0.252-in. specimen, and shall be machined true and axial.

(*c*) A sketch showing the specimen used shall accompany the report of test results.

Testing Machine

4. (*a*) The type of testing machine to be used in long-time (creep) high-temperature tests is not specified, but shall be reported with the results of a series of tests. The applied load shall be calibrated to an accuracy within ±1 per cent. Precaution shall be taken to avoid excessive inertial and frictional effects in the loading mechanism.

Location of Thermocouples

T Inside top end beyond fillet
T_i Inside top end at or within fillet
T_o Outside top end at fillet
C Inside at center of length
C_o Outside at center of length
B Inside bottom end beyond fillet
B_i Inside bottom end at or within fillet
B_o Outside bottom end at fillet

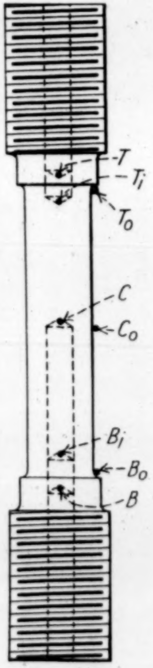


FIG. 2.

	Nominal Test Temperature, deg. Fahr.									
T										
T_i										
T_o										
C										
C_o										
B										
B_i										
B_o										

FORM I.—Form for Reporting Temperature Survey of Furnace

The above form on letter size sheets suitable for recording test data is available in pads of 25 sheets at 50 cents per pad ; 3 pads, $1.00. Address, American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

(*b*) Precautions shall be taken to insure that the testing load is axially applied. Each specimen when set up for test shall be inspected for faulty alignment in the machine. Eccentricity of loading can often be detected by elastic extension measurements taken at room temperature before commencing the test. Apparatus provided with extensometers affording measurements on opposite sides will reveal unsatisfactory alignment when unequal strain is shown by the opposite readings. Elongation measuring devices which show extension on one side of the specimen only do not readily lend themselves to the detection of eccentric loading.

(*c*) *Shackles.*—The type of shackles used to obtain axial loading are not specified, but a detailed description of the shackles used shall be reported with the results of a series of tests.

NOTE.—It is to be noted that eccentricity of loading of the specimen may be lessened by using rods or wire cables of the greatest length possible to connect the shackles to the heads of the testing machine.

Furnace and Heating

5. (*a*) A drawing showing the furnace and heating element in detail shall be submitted with the results of a series of tests.

(*b*) The design of the furnace shall be such that the maximum variation of temperature over the gage length of the calibration bar, shown in Fig. 2 (Form No. I) will not exceed 5 F. for temperatures up to and including 1200 F., 10 F. for temperatures over 1200 F. and up to and including 1600 F., and 20 F. for temperatures over 1600 F.

NOTE.—It should be noted that the transverse dimensions of the furnace should be as small as possible, merely large enough to allow for the shackles and extensometer. Any suitable arrangement of the heating element that will result in the required uniformity of temperature is considered satisfactory. It may be noted that equalization of temperature over the length of the test specimen may be improved by a metallic lining inside the furnace tube, or by the use of multiple heating coils. Liquid baths may be used at lower temperatures provided that no reaction of the liquid upon the test metal occurs. Oil is suitable at lower temperatures. No definite recommendations are made as to the length of the furnace, provided the required uniformity of temperature is realized. Reference to the various publications of the Joint Research Committee is suggested for guidance.

Temperature Measuring Apparatus

6. (*a*) Temperature measurements shall be made by means of suitable thermocouples and potentiometer or millivoltmeter equipment, which shall be accurate to within the following permissible variations for the temperature ranges shown:

	PERMISSIBLE VARIATIONS
Up to and including 1200 F.	± 3 F.
Over 1200 to and including 1600 F.	± 5 F.
Over 1600 F.	± 10 F.

(*b*) The hot junction of the thermocouple shall be located at any one of the locations T, T_o, C_o, B_o, B shown in Fig. 2, and the location of the junction shall be reported with the results of tests. Where external contact is made between thermocouple bead and the specimen, the thermocouple shall be shielded in like manner in the creep tests and in the calibration.

Temperature Survey of Furnace

7. (*a*) A survey of the temperature distribution throughout the test specimens shall be made before making a series of tests of specimens of a given metal, on each furnace and test shackle arrangement used. This survey shall be made using a special calibration bar, shown in Fig. 2, and for each series of tests the calibration bar shall be of the same dimensions, and shall be of the same type chemical composition, as the test specimens to be used. A survey of temperature distribution shall be made for each temperature at which specimens are to be tested, and detailed results of these surveys shall be reported with the results of specimen tests. These surveys furnish data for the comparison of specimen temperature at the point where the thermocouple is applied in routine tests of specimens with the temperature of the test specimen at the middle of the reduced section of the test specimen on the axis of the specimen (C, Fig. 2). The temperature of the calibration bar shall be also determined at the other points indicated in Fig. 2.

(*b*) During a survey of temperature distribution on a calibration, all temperature readings shall be taken as nearly simultaneously as possible.

(*c*) Testing temperature as normally measured during the course of a test shall be corrected, if necessary, using the survey data as a basis of correction. The amount of correction applied shall be the difference between the temperature as normally measured and that found to be the average shown by the survey couples imbedded at the required points.

Room Temperature During Tests

8. During the period of time required for survey tests the range of room temperature shall not exceed 10 F. During creep tests, the room temperature shall be kept as constant as possible, and all

elongation measurements shall be taken when the variation in room temperature does not exceed 10 F. During all tests the equipment shall be shielded from abnormal drafts.

Strain Measurement During Test

9. There shall be reported with the results of all tests, the construction details of the strain measuring apparatus used. Scale divisions on the extensometer shall not be larger than 0.0001 in. per inch of gage length. It is preferable that the extensometer be attached to the gage length of the specimen, or that suitable optical means bearing directly on the gage length of the specimen be used.

Sustained Loads

10. The constant-temperature, constant-stress method shall be employed. Tests shall be made on individual specimens at such loads in round hundreds or thousands of pounds per square inch, suitable to the material and temperatures, and tests shall be made in such number and for such time periods as to achieve the desired object.

Test Procedure

11. The following procedure shall be observed in all tests:

(*a*) It is recommended that not more than one specimen be placed in a furnace at one time, and that each furnace be provided with its own individual control.

(*b*) Before heating, the specimen shall be loaded to check alignment. (See Section 4 (*b*).)

(*c*) During heating to the temperature desired, the test specimen shall not sustain a unit load in excess of 250 lb. per sq. in.

(*d*) The heating period preparatory to loading shall be long enough to establish thermal equilibrium and shall be reported. The load shall then be applied without sudden jolt to the specimen.

(*e*) The immediate elongation in gage length upon application of load shall be observed and reported.

(*f*) Further elongation observations shall be made after intervals of 8 hr., 24 hr., 48 hr., and each 24-hr., 48-hr., or other necessary periods thereafter until the completion of the constant-temperature, constant-stress run. Time intervals shall be such that all characteristics of the elongation will be observed.

(*g*) When the testing of a specimen that is not ruptured is to be discontinued, the elastic recovery or contraction of the gage length upon removal of load shall be observed, before allowing the specimen to cool and this shall be reported.

(*h*) All specimens tested shall be carefully preserved for six months for further studies as to their hardness, microstructure, impact resistance, etc., should such be desired.

FORM II.—FORM FOR REPORTING DATA AND RESULTS OF LONG-TIME (CREEP) HIGH-TEMPERATURE TENSION TESTS.

Test Laboratory..

Material.. Specimen No..

Test Temperature.. Original Stress..

Location of thermocouple..

Sensitivity of elongation measuring device..

Time allowed for equilibrium before loading.............. ....hr............min

Temperature fluctuation of specimen........................ ....deg. Fahr.

Temperature fluctuation of room........................ ....deg. Fahr.

Total elongation, loaded.. ....in.

Creep rate over test period........................... ....per cent

Creep rate during secondary period........................ ....per cent

Immediate extension upon application of load.............. ....in.

Contraction upon removal of load........................ ....in.

Original gage length, room temperature.................. ....in.

Gage length after test, room temperature................. ....in.

Change in gage length, room temperature................. ....in.

ELONGATION

Date	Hours Duration	Total Inches	Inches per Inch	Increment, in. per Inch	Remarks

The above form on letter size sheets suitable for recording test data is available in pads of 25 sheets at 50 cents per pad; 3 pads, $1.00. Address, American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

(*i*) Measurements of gage length shall be made at room temperature before placing the specimen in, and after removing the specimen from the furnace and reported.

Recording and Reporting of Data

12. A uniform system of recording and reporting of data shall be used. The accompanying forms for recording and reporting shall be used so that results from cooperating laboratories may be readily compared.

(*a*) *Reporting Temperature Surveys.*—For reporting the results of the temperature distribution surveys, Form I is recommended.

(*b*) *Reporting Test Data.*—Form II shall be used for reporting the data and results of long-time (creep) high-temperature tests. The data required on Form II are sufficient for completing the time-creep curves and for evaluating creep rates. Under the column "Remarks" shall be noted the increases in stress, temperature fluctuations, etc.

(*c*) *Time-Creep Curves.*—For plotting time-creep curves[1] the following scales shall be used:

SCALE FOR TIME (ABSCISSAS)	SCALE FOR CREEP (ORDINATES)
1 in. = 100 hr.	½ in. = 0.001 in. for creep rates of 1 per cent in 10,000 hr.
1 in. = 100 hr.	½ in. = 0.0001 in. for creep rates of 0.1 per cent in 10,000 hr.

(*d*) *Stress-Temperature Curves.*—For plotting stress-temperature curves[1] the following scales shall be used:

SCALE FOR TEMPERATURE (ABSCISSAS)	SCALE FOR STRESS (ORDINATES)
½ in. = 100 F.	1 in. = 10,000 lb. per sq. in.

Curves showing creep rates in the secondary flow period of 0.01, 0.1, 1,0 or 10 per cent per 10,000 hr. shall be plotted.

(*e*) *Summary of Data.*—In reporting results of long-time high-temperature tension tests full information about material, apparatus and tests methods shall be reported, as follows:

Materials.—The report shall include the following information concerning the materials tested:

Process of manufacture and whether material is rolled, forged or cast.

Complete chemical analysis.

Complete details of heat treatment.

Physical properties of the material at room temperature.

---

[1] Dietzgen No. 340–10 or equivalent cross-section paper is recommended for this purpose.

Size of sample from which specimens were cut.

Relative location and direction of specimen. (Illustrate with sketch.)

If material was removed from service, complete details of service conditions shall be given.

Micro-structure and deep etch of samples.

Test Methods.—The report shall include the following information concerning the apparatus and methods of testing:

Description of apparatus, shackles used, method of calibrating loading mechanism and accuracy of loading.

Description of temperature control-recording arrangement.

Description of furnace.

Description of elongation measuring device.

Radical departures, if any, from recommended procedure and technique.

Sketch of specimen used.

Results of temperature surveys of furnace, Form I (see Paragraph (*a*)).

Test data required on Form II (see Paragraph (*b*)).

Time-creep curves (see Paragraph (*c*)).

Stress-temperature or creep-rate evaluation (see Paragraph (*d*)).

APPENDIX

EVALUATION OF CREEP TEST RESULTS

Test data shall be evaluated on a basis of the *sensitivity* of elongation measurement afforded by the apparatus employed. By sensitivity shall be understood the smallest interval per unit of gage length to which an elongation determination can be reproduced by successive measurements when no permanent deformation has taken place in the interval between readings.

In view of the fact that good sensitivity of elongation measurement and accuracy of creep rate determination are not attainable unless temperature fluctuations are minimized, the following restrictions shall be placed upon the evaluation of tests:

SENSITIVITY OF ELONGATION MEASUREMENT, PARTS PER MILLION OF GAGE LENGTH	PERMISSIBLE TEMPERATURE FLUCTUATION, DEG. FAHR.	SMALLEST RATE OF CREEP REPORTABLE FROM TESTS OVER THE SPECIFIED INTERVAL[a]	MINIMUM TIME PERIOD, HR.
4	1	0.01 per cent per 10 000 hr.	2000
20	2	0.1 per cent per 10 000 hr.	1000
100	5	1.0 per cent per 10 000 hr.	500
500	5	10.0 per cent per 10 000 hr.	250

---

[a] It should be recognized that all these creep rates are extrapolations.

The report shall include information as to the sensitivity, temperature fluctuation, and the actual time yield curves.

TENTATIVE METHODS OF VERIFICATION
OF
TESTING MACHINES[1]

A.S.T.M. Designation: E 4 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED AS TENTATIVE 1923; ADOPTED IN AMENDED FORM, 1924;
REVISED, 1927; REISSUED AS TENTATIVE, 1933; REVISED, 1934.[2]

DEFINITIONS

1. (*a*) *Testing Machine.*—A mechanical device for applying a load (force) to a specimen.

NOTE.—Usually the magnitude of the load can be changed at the will of the operator. Many testing machines are arranged to measure the load, but this is not always the case, especially with impact machines and machines for testing ductility.

(*b*) *Error.*—In the case of a testing machine, the value obtained by subtracting the correct value of the quantity measured (usually load) from the indicated value as given by the testing machine.

NOTE.—The error may be positive or negative.

(*c*) *Percentage of Error.*—In the case of a testing machine, the ratio expressed as a percentage of the error to the correct value of the quantity measured.

(*d*) *Correction.*—In the case of a testing machine, the value obtained by subtracting the indicated value from the correct value of the quantity measured.

NOTE.—The correction has the same magnitude as the error but the opposite sign. It is recommended that, except for special cases, no corrections be used on machines tested and found to have errors within the tolerances given in these methods.

(*e*) *Tolerance.*—In the case of a testing machine, the maximum allowable error in the value of the quantity indicated.

NOTE.—It is convenient to express tolerance in terms of percentage of error. The numerical value of the tolerance for a testing machine is so stated hereafter in these methods.

---

[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee E-1 on Methods of Testing.

These methods are in effect a revision of, and replace the former Standard Methods of Verification of Testing Machines (A.S.T.M. Designation: E 4 - 27), which standard was accordingly discontinued in 1933.

[2] Latest revision accepted by Committee E-10 on Standards, August 22, 1934.

The word "accurate" applied to a testing machine shall be used without numerical values. The word "error" shall be used with numerical values. For example: "An accurate testing machine was used for the investigation"; but "At a load of 30,000 lb. the error of the testing machine was 15 lb." A testing machine is said to be accurate if the indicated load is within the specified tolerance of the actual load.

NOTE.—The *accuracy* of a testing machine should not be confused with *sensitiveness*. For example, a testing machine might be very sensitive, that is, it might indicate quickly and definitely small changes in the load, but, nevertheless, be very inaccurate. On the other hand, the accuracy of the results is, in general, limited by the sensibility.

(*f*) *Loading Range.*—The loading range of a testing machine or of an apparatus for calibrating a testing machine is the range of indicated loads for which the testing machine or the calibrating apparatus gives results within the tolerances specified.

(*g*) *Elastic Calibration Device.*—An elastic calibration device for use in verifying the load readings of a testing machine consists of an elastic member to which loads may be applied combined with a mechanism for indicating the magnitude of deformation under load.

METHODS FOR VERIFYING TESTING MACHINES THAT MEASURE LOAD

Advantages and Limitations of Different Methods

2. Four methods of verifying testing machines are listed in this standard:

(*a*) *Standard Weights.*—Verification by the direct application of standard weights to the weighing mechanism of the testing machine, where practicable, is the most accurate method. Its limitations are (*1*) the small range of load which can be covered, (*2*) the non-portability of any large amount of standard weights, and (*3*) its non-applicability to horizontal testing machines.

(*b*) *Proving Levers.*—Verification by the use of standardized proving levers loaded with standard weights ranks second in accuracy. Its limitations are (*1*) the fact that the range of load possible with proving levers, while greater than with standard weights, is not great enough to cover the capacity range of large testing machines, and (*2*) the inconvenience of transportation of proving levers and standard weights for verifying large testing machines.

(*c*) *Elastic Calibration Device.*—Verification by the use of an elastic calibration device ranks third in accuracy. It is free from the limitations of the methods referred to in Paragraphs (*a*) and (*b*).

(*d*) *Comparison Method.*—Verification by a comparison of the tensile strength of test specimens ("companion specimens") cut from the same piece of metal, is distinctly less accurate than the three methods referred to in Paragraphs (*a*), (*b*) and (*c*), and should be used only when none of the other methods are available. If the results of a verification test by the comparison method fail to agree with the results of a verification test by any of the other three methods, the results given by the comparison method shall be discarded.

Method of Applying Load

3. In the verification of a testing machine the loads shall be applied in ascending order.

NOTE.—For machines in which the load-indicating device is actuated by a Bourdon pressure tube, a hydraulic (or steam-engine) indicator spring, or other device depending on the elastic properties of a material, the tolerances for the *descending* load shall be applied to differences in the indication for the corresponding ascending and descending readings. In such testing machines the test for ascending load shall be applied as rapidly as practicable after the testing machine has remained unloaded for at least 6 hr., and the time of applying the ascending series of loads shall not exceed 30 minutes. The descending load test shall be made after the maximum test load has remained on the machine for 1 hr., and the readings for descending loads shall be taken as rapidly as possible, and in any event the descending load test shall be completed within a period of 20 minutes.

Selection of Test Loads

4. For any loading range, the testing machine shall be verified by at least five test loads (except for testing machines designed to measure only a smaller number of definite loads, such as certain hardness testing machines). The difference between any two successive test loads shall not exceed one third of the difference between the maximum and minimum test loads.

NOTE.—A testing machine may have more than one loading range. For instance, a 100,000-lb. capacity testing machine may have one loading range from 5000 lb. to 40,000 lb. and a second loading range from 55,000 lb. to 100,000 lb. Section 4 requires that the machine must be verified by at least five test loads between 5000 lb. and 40,000 lb. and also that the machine must be verified by at least five test loads between 55,000 lb. and 100,000 lb.

Eccentric Loading

5. For the purpose of determining the loading range of a testing machine all calibration loads shall be applied so that the resultant load shall be as nearly along the axis of the testing machine as is possible.

NOTE.—The effect of eccentric load on the accuracy of a testing machine may be determined by calibration readings taken with proving levers or an elastic calibration device placed so that the resultant load is applied at definite distances from the axis of the machine, and the loading range determined for a series of eccentricities. In the case of testing machines in which the load reading depends on the hydrostatic pressure in a cylinder fitted with a piston the effect of eccentricity of loading is most serious when the piston is at the extreme outward position allowable.

A. Method of Verification by Standard Weights

Method by Standard Weights

6. Standard metal weights of suitable design, finish, and adjustment shall be placed on the weighing platform of the testing machine or upon trays or other supports suspended from the load-measuring mechanism in place of the specimen. The weights shall be applied in increments and removed in the reverse order. They shall be arranged symmetrically with respect to the weighing platform, so that the center of gravity of the load lies in the vertical line through the center of the platform. The applied load and the indicated load hall be recorded for each test load applied, and the error calculated from these data.

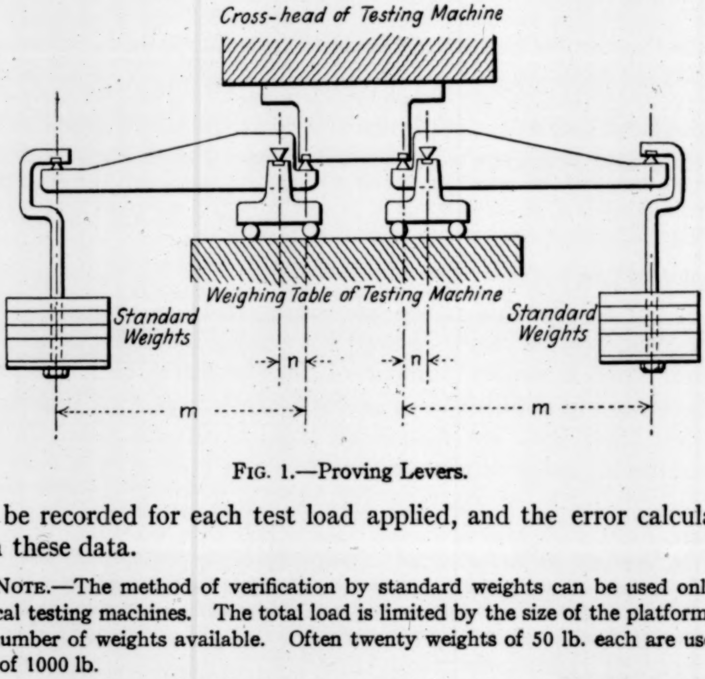

Cross-head of Testing Machine
Weighing Table of Testing Machine
Standard Weights
Standard Weights
n
n
m
m

FIG. 1.—Proving Levers.

NOTE.—The method of verification by standard weights can be used only on vertical testing machines. The total load is limited by the size of the platform and the number of weights available. Often twenty weights of 50 lb. each are used, a total of 1000 lb.

This method of verification is seldom used for any but small testing machines, as the loading range does not include the loads for which large machines are used.

B. Method of Verification by Standardized Proving Levers

Description of Levers

7. The arrangement of proving levers for verifying testing machines is shown in Fig. 1. The two levers rest on supports on the weighing platform of the testing machine. These supports shall move easily in a horizontal direction, which insures that the forces at each of the knife edges shall be very nearly vertical. The inner knife

edges in each lever bear against a suitable block in the movable head of the testing machine. Weight trays or hangers are suspended from each of the outer knife edges and these trays or hangers are loaded with standard weights. The increment of load put on the testing machine by the standard weights is the amount of standard weights multiplied by the lever ratio m/n, Fig. 1.

Specifications of Levers

8. The knife edges, as well as their supports, shall be of hardened tool steel. The knife edges shall be ground sharp to an angle of 90 deg. The load on any knife edge shall not exceed 7000 lb. per linear inch. The three knife edges in each lever shall be parallel, and their edges shall lie in a plane. Each lever shall have machined surfaces in this or in some parallel plane, upon which a spirit level can be placed.

Verification of Levers

9. The lever ratio of a proving lever shall be determined by the use of at least three test loads; the amount of weights used shall not be less than the maximum load applied upon one of the arms of a lever in using the levers to verify testing machines. The proving lever shall be balanced over its center knife edge with suitable weight trays suspended from the end knife edges. Standard weights shall then be applied to the trays in three steps, corresponding approximately to 50, 75, and 100 per cent of the weights available, and the proving lever shall then be brought to a balance by the use of small weights and by observations of the freely swinging proving lever. From the weights in the two weight trays the lever ratio shall be calculated.

Method of Procedure

10. The proving levers shall be placed symmetrically in the testing machine to be verified and both levers brought as near to a horizontal position as is feasible, after applying each increment of load, by means of the movable head of the testing machine. The testing machine shall be balanced with the levers in place and the weight trays empty. Standard weights shall be applied (or removed) in increments, half an increment in (or from) each tray. The weights shall be placed symmetrically on the weight trays, with the center of gravity of the weights over the center of the tray. The applied load and the indicated load shall be recorded for each test load applied, and the error calculated from these data.

NOTE.—The method of verification by standardized proving levers is used, at the present time, only on vertical testing machines. It is often used up to loads of 10,000 lb.

C. Method of Verification by Means of an Elastic Calibration Device[1]

Design and Workmanship

11. An elastic calibration device should be so designed and constructed that its accuracy is not in danger of being impaired by handling, shipping, or ordinary use, and so that parts subject to damage, replacement, or removal for storage and shipment can be replaced without impairing the accuracy of the device.

NOTE.—This section is non-quantitative in its requirements. It is placed in the method for the purpose of calling attention to the fact that an elastic calibrating device if improperly designed and constructed may, like any other delicate measuring instrument, be damaged and rendered inaccurate by handling and shipping.

Shackles and Bearing Blocks

12. An elastic calibration device shall be provided with shackles, bearing blocks, or any other necessary fixtures through which the load is to be applied to the calibration device. All such fixtures should be so designed and constructed that when placed in a testing machine in reasonably good condition there shall be no extra-tolerance variation of reading due to imperfections in the bearing blocks or in the motion of the head of the testing machine.

NOTE.—This section is non-quantitative in its requirements. It is placed in the method for the purpose of calling attention to the fact that poorly designed loading fixtures can render inaccurate the readings of an elastic calibration device.

Graduation of Scale

13. (*a*) The scale of the indicating mechanism shall be uniformly graduated. The distance between any two graduation lines, dots, or other dividing marks shall be not less than 0.035 in.

(*b*) The difference between the position of any graduation line and its correct position on the scale shall not exceed one twentieth of the distance between two adjacent graduation lines.

(*c*) For each division of the scale, the change in load required to change the reading from one graduation line to an adjacent graduation line shall not exceed one fifth of 1 per cent of the capacity load.

Label Showing Manufacturer, Number, and Capacity

14. The manufacturer's name, the capacity load, and the serial number of the device shall be legibly marked on some part of the instrument.

Temperature Equalization

15. When using an elastic calibration device to verify the load readings of a testing machine the device should be placed near, or

---

[1] The term "calibration device" shall be interpreted to include solid bars, hollow bars, elastic loops, and other members whose elastic deformation can be measured.

preferably in, the testing machine a sufficient length of time before the test so that the device and the testing machine shall be at very nearly the same temperature.

Preliminary Cyclic Loading

16. Before taking readings for the formal verification of an elastic calibration device by means of dead weights or other primary standards, the device shall be subjected to a series of cyclic loads varying from a minimum load not greater than 2 per cent of the capacity load of the device to a maximum load not less than 5 per cent nor more than 10 per cent above the nominal capacity load.

Elimination of Small Temperature Effects due to Stress

17. To minimize errors due to temperature effect of stress and psuedo-elastic action, the time schedule followed when verifying an elastic device which is loaded in axial tension or compression shall be reported; and the same time schedule, within limits stated in the report, shall be followed when using the device to calibrate a testing machine.

Primary Standards for Elastic Calibration Devices

18. (*a*) For loads not exceeding 100,000 lb. an elastic calibration device shall itself be calibrated by applying dead weights known to be accurate within 0.02 per cent.

For loads exceeding 100,000 lb. an elastic calibration device may be calibrated by another elastic calibration device or by a combination of several elastic calibration devices, or by proving levers[1] and dead weights. In this case the calibrating load applied shall be known to be accurate within 0.1 per cent.

Routine in Calibration of Elastic Calibration Device

19. For any range of test loading which may be applied in calibrating an elastic calibration device there shall be applied at least eight test loads, and the difference between any two successive test loads shall not exceed one fifth of the difference between the minimum and the maximum test loads. The series of test loads shall be applied to the elastic calibration device at least three times, and the shackles or bearing blocks shall be readjusted before each application of a series of loads.

---

[1] The term "proving levers" is not to be interpreted as allowing the use of the lever system of a compound lever testing machine or of a platform scale as a part of a primary standard.

Tolerance for Elastic Calibration Device

20. (*a*) For ordinary use the loading range of an elastic calibration device shall be that range of load within which any reading under an applied load shall not differ from the average of at least three readings under the same load by more than one fifth of 1 per cent.[1]

(*b*) The report of the verification of the elastic calibration device shall also state the loading range within which no reading varies from the average of at least three readings under the same load by more than one tenth of 1 per cent. This range shall be designated as the *Precision Loading Range* for the device.

Temperature Correction for Elastic Calibration Device

21. In using an elastic calibration device made of steel with not more than 5 per cent of alloying elements, a fairly accurate correction for variation in temperature may be made on the basis that the modulus of elasticity in tension or compression (or flexure) diminishes by 0.015 per cent for each degree Fahrenheit increase in temperature. For other metals, if the change in the modulus of elasticity with temperature is known, a correction for temperature should be applied to the readings of the instrument. During any calibration of a testing machine with an elastic calibrating device, or during the calibration of the device itself temperature shall be kept as uniform as possible.[2]

D. *Verification by Companion Specimen Method*

Description of Comparison Method

22. When the direct method of verification of a testing machine cannot be carried out (as is the case at present with horizontal testing machines, for example), or when an elastic calibration device is not available, a comparison method of verification may be used. In this method the machine to be verified is tested by comparing its indications with the corresponding readings obtained under the same conditions by the use of another testing machine, especially tested and verified, as specified in Section 23. The method of verification by comparison shall be carried out by the use of a series of companion specimens, half of which are to be tested in tension in the machine

---

[1] This means that the report of a standardizing laboratory on an elastic calibration device will state *within what loading range* it may be used, rather than reporting a blanket acceptance or rejection of the device. This follows the practice recommended for testing machines.

[2] Similar errors due to change of modulus of elasticity with temperature may be present in the load-indicating mechanism of a testing machine using a Bourdon gage or other device dependent on the elastic deformation of a member.

to be verified, and half of which are to be tested in tension in the especially verified testing machine which serves as a standard machine. The general provisions respecting the application of the test loads and the loading range which are outlined in the direct method of verifying testing machines (Sections 3, 4 and 5) shall apply to the verification of testing machines by the comparison method, so far as is practicable.

Requirements for Testing Machines Used for Verifying Other Machines

23. (*a*) A testing machine which is to be used as the standard for verifying other testing machines shall itself be verified by a special test, in which the verification is carried out twice. The loading range shall be determined by the tolerance of ±1 per cent (Section 27). For the loading range established, the differences in indications found in the two tests of the standard machine shall not exceed 0.25 per cent.

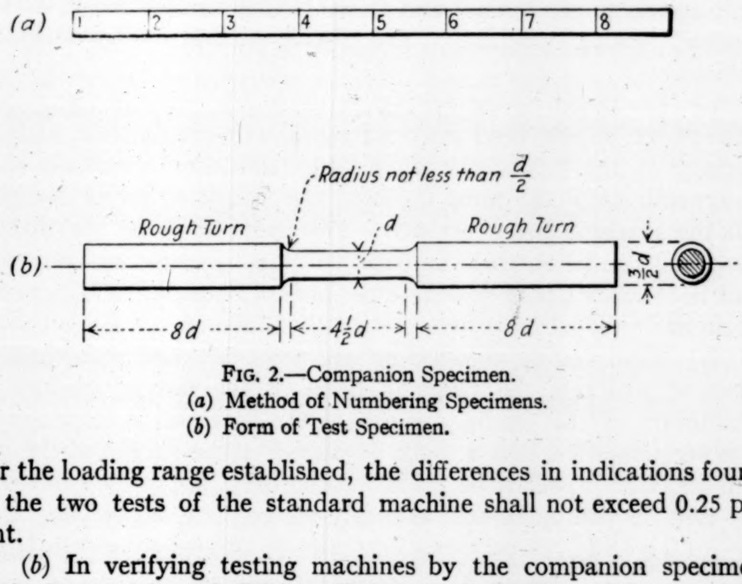


FIG. 2.—Companion Specimen.
(*a*) Method of Numbering Specimens.
(*b*) Form of Test Specimen.

(*b*) In verifying testing machines by the companion specimen method, corrections shall be applied to the indications of the standard machine and these corrections shall be based on the average correction obtained in the two tests used in its verification.

Test Specimens

24. (*a*) For each test load, eight or more tension test specimens shall be cut from soft rolled or drawn steel and numbered consecutively, as in Fig. 2 (*a*).

(*b*) The tensile strength of the steel shall be determined by a preliminary test and the sets of specimens for the comparison test shall have such nominal cross-sectional areas as will give, approximately, the loads required. The form of the specimen shall be as shown in Fig. 2 (*b*). The ends may be threaded, or otherwise machined, to fit holders, but it is recommended that those specimens shipped to another laboratory be left with cylindrical ends. The actual value of "*d*" (Fig. 2 (*b*)) for each specimen shall be determined by means of a micrometer.

NOTE.—It should be noted that the standard tension test specimen, 0.5 in. in diameter and having a 2-in. gage length, satisfies the requirements for a specimen for the verification of a testing machine by the comparison method. See Fig. 9 of the Standard Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8) of the American Society for Testing Materials.[1]

Method of Procedure

25. (*a*) The specimens having odd numbers shall be tested in the machine to be verified and those having even numbers in the standard testing machine. The tensile strength only shall be determined.

(*b*) The speed of the testing machine, by which is meant the speed of the pulling head when the machine is running idle with no specimen in the machine, when testing verification specimens shall be approximately the same for both the standard testing machine and the machine being verified. The speed shall be the slowest speed that can be obtained on both machines; in any case the speed shall not exceed 1 in. per minute per inch of diameter of companion specimen.

(*c*) When testing companion specimens, especial care shall be taken to maintain the weighing beam of the testing machine in equilibrium as the tensile strength of the specimen is approached. It is recommended that a mark be placed at the middle of the trig loop and that a pointer be placed on the beam for verification tests, and that the pointer be kept as nearly on the mark as possible.

Computation of Error

26. (*a*) The average tensile strength (in pounds per square inch) of the odd-numbered specimens, multiplied by the nominal area of cross-section, shall be considered a measure of the indicated load, and the average tensile strength of the even-numbered specimens, multiplied by the nominal area of cross-section, shall be considered a measure of the applied load. The error shall be calculated from these data.

(*b*) If the tensile strength (in pounds per square inch) of any companion specimen varies more than 1 per cent from the mean of the group with which it is tested, its tensile strength shall not be used in computing the error of the testing machine. If more than one specimen in the odd-numbered group or more than one specimen in the even-numbered group exceeds the allowable variation in tensile strength, all the specimens shall be discarded and another set prepared.

---

[1] 1933 Book of A.S.T.M. Standards, Part I, p. 949.

TOLERANCES FOR TESTING MACHINES THAT MEASURE LOAD

Tolerance Within Loading Range of a Testing Machine

27. The error for loads within the loading range of a testing machine shall not exceed 1 per cent (Notes 1 and 2).

NOTE 1.—This means that the report of the verification of a testing machine will state ***within what loading range it may be used***, **rather than reporting a blanket acceptance or rejection of the machine.**

NOTE 2.—In no case shall the loading range be stated as including loads below a value which is 100 times the smallest load which can be read on the testing machine. (This means that if a testing machine had graduations so spaced that it can be read to within $\frac{1}{10}$ division and the machine is sensitive to $\frac{1}{10}$ division it would be possible for the loading range to extend down to the load corresponding to 10 divisions. On the other hand, if the testing machine was sensitive to only 2 divisions, the loading range could not extend below the load corresponding to 200 divisions.)

Corrections

28. The indicated load of a testing machine shall not be corrected either by calculation or by the use of a calibration diagram to obtain values within the required tolerance.

TIME INTERVAL BETWEEN VERIFICATIONS

Time Interval Between Verifications

29. It is recommended that testing machines, when in constant use, be verified at intervals of six months and, when used intermittently, at intervals of two or three years. Testing machines shall, however, be verified immediately after making repairs or adjustments of the weighing mechanism, and whenever there is reason to doubt the accuracy of the results, without regard to the time interval since the last verification.

REPORTS AND CERTIFICATES

Reports

30. A clear and complete report shall be prepared of each verification of a testing machine. This report shall state the method of verification used, and shall give the serial numbers and the names of manufacturers of all apparatus used in carrying out the verification.

It shall state how and by whom and when the calibration of the apparatus used in verifying the testing machine was made, the loading range, and the "precision" loading range of the calibration apparatus, and of the testing machine.

Certificates

31. A certificate giving the manufacturer's serial number and a brief description of the testing machine, the manufacturer's name, the date of verification, and the loading range, shall be signed by the person responsible for the maintenance of the testing machine, and this certificate shall be posted in plain view of a person operating the testing machine.

TENTATIVE DEFINITIONS OF THE TERMS CONSISTENCY AND PLASTICITY[1]

A.S.T.M. Designation: E 24 - 34 T

This is a **Tentative Standard** and under the Regulations of the Society is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

ISSUED, 1934.[2]

Consistency.—That property of a material other than a gas by virtue of which it resists the stresses which produce permanent change of shape.

NOTE 1.—Consistency is expressed by the three following flow-force relations:

Simple (Newtonian) *Liquid.*[3]—When the ratio of flow to force is constant, the material is said to be a simple liquid.

The simple liquid under conditions of non-turbulent flow follows Newton's law, which may be written, $v = \phi F r$, where v is the velocity imparted by the stress F per unit area, to either of two parallel planes separated by the distance r, the space between the planes being filled with the liquid. The constant ϕ is known as the *fluidity* which is the reciprocal of the *viscosity.*

Solid.—Any body which requires a finite stress to produce a permanent deformation is a solid.

Non-Newtonian Liquid.[3]—A body which yields permanently under very small stresses and yet is not a simple liquid is known as a non-Newtonian liquid.

NOTE 2.—The term consistency may be used irrespective of whether the body is a liquid or a solid.

Plasticity.—That property of a solid by virtue of which it is permanently deformed when stressed above the yield value. This is a complex property and therefore cannot be represented quantitatively by a single numerical value. The factors which define plasticity are the yield value and the mobility:

Yield Value,[4] θ.—The minimum stress required to produce a permanent deformation in a solid.

Mobility, μ.—The coefficient in the law of plastic flow, $v = \mu (F - \theta) r$, where v is the velocity imparted by the stress F per unit area, to either of two parallel planes separated by the distance r, the space between the planes being filled with the plastic material.

---

[1] Under the standardization procedure of the Society, these definitions are under the jurisdiction of the A.S.T.M. Committee E-1 on Methods of Testing.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 22, 1934.

[3] Gases have not been considered in the formulation of these definitions.

[4] Attention is called to the fact that yield value is defined very similarly to the present definition for elastic limit. The definition for elastic limit is of course defined having in mind the principal mechanical tests, and effort is being made to reconcile the usages of these terms and definitions.

TENTATIVE REVISIONS
OF
A.S.T.M. STANDARDS

Tentative revisions of A.S.T.M. Standards are printed for one or more years with a view of eliciting criticisms, of which the committee concerned will take due cognizance before recommending final action.

Members of the Society and others are invited to direct written criticisms of any of these Tentative Revisions to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

TENTATIVE REVISIONS OF A.S.T.M. STANDARDS

Revision[1] of Standard Specifications for Open-Hearth Carbon-Steel Rails (A.S.T.M. Designation: A 1 – 30):[2]

Section 3.—Change the table of chemical requirements, appearing in this section, to read as follows by the addition of the italicized figures and the omission of those in brackets:

Elements Considered	Weight, lb. per yd.				
	50–69	70–84	85–100	101–120	121–140
Carbon, per cent	0.50–0.63	0.53–0.70	[0.62] *0.64*–0.77	0.67–[0.83] *0.80*	[0.72–0.89] *0.69–0.82*
Manganese, per cent	0.60–0.90	0.60–0.90	0.60–0.90	[0.50–0.90] *0.70–1.00*	[0.50–0.90] *0.70–1.00*
Phosphorus, max., per cent	0.04	0.04	0.04	0.04	0.04
Silicon, min., per cent	[0.15] *0.10–0.23*	[0.15] *0.10–0.23*	[0.15] *0.10–0.23*	[0.15 *0.10–0.23*	[0.15] *0.10–0.23*

Revision submitted, June, 1934.

Section 12.—Change this section to read as follows by the addition of the italicized words and the omission of the word in brackets:

12. The section of the rails shall conform as accurately as possible to the templates *or drawings* furnished by the purchaser. A variation of $\frac{1}{64}$ in. less and $\frac{1}{32}$ in. greater than the specified height will be permitted. A variation of $\frac{1}{16}$ in. in the [length] *width* of either flange will be permitted, but the variation in total width of base must not exceed $\frac{1}{16}$ in. No variation will be allowed in dimensions affecting the fit of the joint bars, except that the fishing template approved by the purchaser may stand out not to exceed $\frac{1}{16}$ in. laterally.

Revision submitted, June, 1934.

Section 18.—Add to the first sentence of Paragraph (*b*) a reference to the A.R.E.A. type rails, thus making the opening phrase read: "Rails of A.R.A. or A.R.E.A. type of sections."

Add the following as a new Paragraph (*c*):

(*c*) Rails that are not hot stamped.

Revision submitted, June, 1934.

Section 19.—Change this section from its present form to read as follows:

(*a*) The data and order of arrangement of the branding shall be as shown in the following typical branding, the design of letters and numerals to be optional with the manufacturer:

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

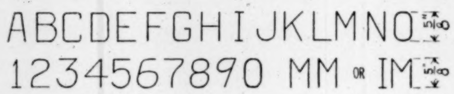
[2] 1933 Book of A.S.T.M. Standards, Part I.

11025	R.E.	O.H.	DOE	1930	IIIIII
(Weight and Section Number)	(Type)	(Kind of Steel)	(Manufacturer and Mill)	(Year Rolled)	(Month Rolled)

(*b*) The heat number and the ingot number as rolled shall be stamped in the web of each rail where it will not be covered by the joint bars. The data used in stamping and arrangement thereof shall be as shown in the following typical stamping:

Example 1:	63345	E	17
	(Heat Number)	(Rail Letter)	(Ingot No.)
Example 2:	49021	A	5

(*c*) The top rails shall normally be lettered "A," and succeeding ones "B," "C," "D," "E," etc., consecutively, but in case top discard is greater than normal, the rail lettering shall conform to the amount of discard, the top rail becoming "B," or other succeeding letter to suit the condition. Design and size of letters and numerals to be used in stamping shall be as here shown:



(*d*) Only the "A," "B" and "C" rails are required to be lettered when the normal weight per yard is less than 70 lb. Revision submitted, June, 1934.

Section 20 (*e*).—Change from its present form: namely,

(*e*) All rails of heats the carbon content of which exceeds the mean carbon percentage of the specific range shall have both ends painted blue.

Individual rails shall be painted only one color, according to the order of precedence listed above.

to read as follows:

(*e*) All rails of a heat whose carbon content is in the upper five points of the carbon percentage of the specified range shall have both ends painted blue.

Individual rails shall be painted only one color, according to the order of precedence listed above. Revision submitted, June, 1934.

Section 23 (*c*).—Change to read as follows by the addition of the italicized words:

(*c*) Rails accepted will be paid for according to actual weights, ***subject to the limitations of Section 13.*** Revision submitted, June, 1934.

Revision[1] of Standard Specifications for Carbon-Steel Car and Tender Axles (A.S.T.M. Designation: A 21 – 27):[2]

Section 1.—Change this section to read as follows by the addition of the italicized words and the omission of the word in brackets:

1. These specifications cover tapered axles up to and including those 6½ in. in nominal diameter at the center. Axles over 6½ in. in ***nominal*** diameter at the center ***which*** shall be annealed, [and] shall be in accordance

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part I.

with the Tentative Specifications for Carbon-Steel Forgings for Locomotives (A.S.T.M. Designation: A 20 - 31 T) of the American Society for Testing Materials.[1]

Note.—Add the following Note to Section 1:

NOTE.—Axles with parallel sides, either untreated or annealed as specified, shall be in accordance with the Tentative Specifications for Carbon-Steel Forgings for Locomotives (A.S.T.M. Designation: A 20 - 31 T) of the American Society for Testing Materials.[1]

Revision submitted, June, 1934.

Section 3.—In the table of chemical requirements change the present range in manganese content from "0.40 to 0.70 per cent" to read "0.40 to 0.90 per cent."

Revision submitted, June, 1934.

Section 8.—Add the following paragraph as Paragraph (*b*), lettering the present section as Paragraph (*a*):

(*b*) When less than 15 tons of any one design are ordered, the manufacturer shall have the option of making axles from a previously tested melt and furnishing copy of such test, or of making a tension test to the requirements for untreated forgings as specified in the Tentative Specifications for Carbon-Steel Forgings for Locomotives (A.S.T.M. Designation: A 20 - 31 T) of the American Society for Testing Materials.[1]

Revision submitted, June, 1934.

Section 9.—Change this section from its present form: namely,

9. (*a*) All axles shall be made and finished in a workmanlike manner and shall conform to the sizes and shapes specified by the customer and all journals and wheel seats shall be rough turned. In centering, unless otherwise specified, 60-deg. centers shall be used, with large diameter of counter-sink not less than ⅞ in. and with clearance drilled ½ in. deep.

(*b*) Unless otherwise specified, axles shall be smooth forged, except the wheel seats and journals, which shall be rough turned.

to read as follows:

9. The axles shall conform to the sizes and shapes specified by the purchaser. Unless otherwise specified, axles shall have smooth-forged finish except on wheel seats and journals, which shall be rough turned. Centering shall be 60 deg. with clearance drilled for points.

Revision submitted, June, 1934.

Revision[2] of Standard Specifications for Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A.S.T.M. Designation: A 19 - 27):[3]

Section 5.—Change from its present form: namely,

5. (*a*) Unless otherwise specified by the purchaser, all forgings over 7 in. in diameter shall be bored, and all axles, shafts and similar forgings shall be rough-turned all over. The boring shall be done before quenching.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 662 (1931); also 1934 Book of A.S.T.M. Tentative Standards, p. 34.

[2] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[3] 1933 Book of A.S.T.M. Standards, Part I.

(*b*) If boring is specified, the diameter of the hole shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

to read as follows:

5. (*a*) Unless otherwise specified by the purchaser, all axles, shafts and similar forgings having a minimum diameter over 7 in. shall be bored. The boring shall be done before quenching.

(*b*) In the case of boring, the diameter of the hole, unless otherwise specified, shall be at least 20 per cent of the maximum outside diameter of the forging, exclusive of collars and flanges.

Revision submitted, June, 1931.

Revision[1] of Standard Specifications for Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A.S.T.M. Designation: A 63 - 27):[2]

Section 5.—Make the same change in this section as recommended in Section 5 of Specifications A 19 - 27 above.

Revision submitted, June, 1931.

Revision[1] of Standard Specifications for Wrought Solid Carbon-Steel Wheels for Electric Railway Service (A 25 - 24):[2]

Section 3.—Separate composition for acid steel is to be eliminated and the same chemistry used for both acid and basic steel. It is accordingly recommended that the table of chemical requirements appearing in this section be changed from its present form: namely,

	ACID	BASIC
Carbon, per cent	0.60 - 0.80	0.65 - 0.85
Manganese, per cent	0.55 - 0.80	0.55 - 0.80
Phosphorus, per cent	not over 0.05	not over 0.05
Sulfur, per cent	not over 0.05	not over 0.05
Silicon, per cent	0.15 - 0.35	0.10 - 0.30

to read as follows:

Carbon, per cent	0.65 to 0.85
Manganese, per cent	0.60 to 0.85
Phosphorus, max., per cent	0.05
Sulfur, max., per cent	0.05
Silicon, min., per cent	0.15

Revision submitted, June, 1934.

Section 5.—Change this section from its present form: namely,

5. An analysis may be made by the purchaser from a wheel representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3. A sample may be taken from any one point

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part I.

in the plate; or two samples may be taken, in which case they shall be on radii at right angles to each other. Samples shall not be taken in such a way as to impair the usefulness of the wheel. Drillings for analysis shall be taken by boring entirely through the sample parallel to the axis of the wheel; they shall be clean and free from scale, oil and other foreign substances. All drillings from any one wheel shall be thoroughly mixed together.

to read as follows:

5. An analysis may be made by the purchaser from a wheel block or from a finished wheel selected by his representative from each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3. Samples from wheel blocks shall be drilled from the end of the block at any point midway between the center and outside. The finished wheels may be sampled by taking drillings direct from the plate, or from the slug hot-punched or cored out of the plate; taken so that it does not impair the usefulness of the wheel. Samples shall be taken by drilling entirely through the plate or slug. Drillings from any one block or wheel shall be thoroughly mixed together and they shall be clean and free from scale, oil and other foreign substances.

Revision submitted, June, 1934.

Section 7.—The present permissible variations are intended for wheels operating on T-rails. It is now proposed to include variations for wheels operating on grooved rails which will be one-half of the existing tolerances. It is accordingly recommended that Paragraphs (*a*), (*b*), (*c*), and (*j*) be changed to read as follows by the addition of the italicized words and figures:

(*a*) Height of Flange.—The height of flange shall not vary from that specified by more than $\pm\frac{1}{16}$ in. *for wheels operating on T-rails, nor more than* $\pm\frac{1}{32}$ *in. for wheels operating on grooved rails.*

(*b*) Thickness of Flange.—The thickness of flange shall not vary from that specified by more than $\pm\frac{1}{16}$ in. *for wheels operating on T-rails, nor more than* $\pm\frac{1}{32}$ *in. for wheels operating on grooved rails.*

(*c*) Radius of Throat.—The radius of throat shall not vary from that specified by more than $\pm\frac{1}{16}$ in. *for wheels operating on T-rails, nor more than* $\pm\frac{1}{32}$ *in. for wheels operating on grooved rails.*

(*j*) Limit-of-Wear Groove.—When a limit-of-wear groove is specified, its location shall not vary from that specified by more than $\pm\frac{1}{16}$ in. *for wheels operating on T-rails, nor more than* $\pm\frac{1}{32}$ *in. for wheels operating on grooved rails.*

It is also recommended that Paragraphs (*g*) and (*h*) which read as follows be deleted from this section:

(*g*) *Rotundity.*—The tread shall be gaged with a ring gage, and the opening between the tread and this gage at any point shall not exceed $\frac{1}{16}$ in.

(*h*) *Block Marks on Tread.*—Block marks shall not exceed $\frac{1}{64}$ in. in height.

Table I.—Change Table I in accordance with the modifications being made in Section 7 (*a*), (*b*), (*c*), (*g*), (*h*), and (*j*).

Revision submitted, June, 1934.

Revision[1] of Standard Specifications for Boiler Rivet Steel and Rivets (A.S.T.M. Designation: A 31 – 24):[2]

Section 2.—In the table of chemical requirements change the present requirement for sulfur from "not over 0.045 per cent" to read "not over 0.05 per cent."

Revision submitted, June, 1934.

Revision[1] of Standard Specifications for Structural Rivet Steel (A.S.T.M. Designation: A 141 – 33):[2]

Section 2.—Make the same change in this section as recommended in Section 2 of Specifications A 31 – 24 above.

Revision submitted, June, 1934.

Revision[1] of Standard Specifications for Structural Steel for Ships (A.S.T.M. Designation: A 131 – 33):[2]

Section 2.—In the table of chemical requirements change the present sulfur requirement for structural steel and steel for cold bending from "not over 0.06 per cent" to read "not over 0.05 per cent."

Revision submitted, August, 1934.

Also change the present sulfur requirement for rivet steel from "not over 0.045 per cent" to read "not over 0.05 per cent."

Revision submitted, June, 1934.

Section 5.—Change this section by the addition of the following clause as a new Paragraph (*b*), relettering the present Paragraph (*b*) as Paragraph (*c*):

> (*b*) Flat rolled steel $\frac{3}{16}$ in. and under in thickness, shapes less than 1 sq. in. in cross-section, and bars, other than flats, less than $\frac{1}{2}$ in. in thickness or diameter, shall not be subjected to tension tests.

Revision submitted, June, 1934.

Section 6 (a).—Change this paragraph to provide a minimum elongation in 8 in. of 18 per cent for thicknesses over $\frac{3}{4}$ in. by the addition of the italicized words and figures and by the omission of those in brackets:

> 6. (*a*) For material over $\frac{3}{4}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 5 (*a*) of 0.25 per cent, shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness or diameter above $\frac{3}{4}$ in. to a minimum of [16] *18* per cent for *both* the structural [grade and 18 per cent for] *and* the rivet steel and cold bending grades.

Revision submitted, August, 1934.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part I.

Revision[1] of Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A.S.T.M. Designation: A 15 – 33):[2]

Section 13.—Change this section to read as follows by the addition of the italicized words and figures:

13. The weight of any lot of bars shall not vary more than 3½ per cent over and under the theoretical weight for bars ⅜ in. and over in diameter; nor more than 5 per cent over and under for bars under ⅜ in. in diameter. *The weight of any individual bar shall not vary more than 6 per cent under the theoretical weight for bars ⅜ in. and over in diameter; nor more than 10 per cent under the theoretical weight for bars under ⅜ in. in diameter.* The theoretical weight of deformed bars shall be the theoretical weight of plain round or square bars of the same nominal size. The term "lot" used in this paragraph means all the bars of the same nominal weight per linear foot in a carload.

Revision submitted, June, 1934.

Revision[1] of Standard Specifications for Rail-Steel Concrete Reinforcement Bars (A.S.T.M. Designation: A 16 – 33):[2]

Section 9.—Make the same change in this section as recommended in Section 13 of Specifications A 15 – 33 above.

Revision submitted, June, 1934.

Revision[1] of Standard Specifications for Welded and Seamless Steel Pipe (A.S.T.M. Designation: A 53 – 33):[2]

Section 1.—Add the following Note to this section:

NOTE: *Galvanizing.*—Galvanized pipe, not subject to coiling, bending or flanging, may be purchased under these specifications. When physical tests are made on galvanized samples, any flaking or cracking of the zinc coating shall not be considered cause for rejection. Galvanizing requirements shall be in accordance with the Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A.S.T.M. Designation: A 120 – 34 T) of the American Society for Testing Materials.[3]

Revision submitted, June, 1934.

Section 5 (a).—In the table of physical properties, appearing in this section, change the minimum elongation in 2 in. specified for the open-hearth or electric-furnace seamless low-carbon grade of pipe from the present requirement of "30 per cent" to read "35 per cent."

Revision submitted, August, 1934.

Revision[1] of Standard Specifications for Carbon-Steel Castings (A.S.T.M. Designation: A 27 – 24):[2]

The Tentative Specifications for Carbon-Steel Castings for Industrial, Railroad and Marine Uses (A 154 – 33 T)[4] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications A 27 – 24 and A 87 – 27.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part I.

[3] See p. 604.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 544 (1933); also 1934 Book of A.S.T.M. Tentative Standards, p. 19.

Revision[1] of Standard Specifications for Carbon-Steel Castings for Railroads (A.S.T.M. Designation: A 87 – 27):[2]

The Tentative Specifications for Carbon-Steel Castings for Industrial, Railroad and Marine Uses (A 154 – 33 T)[3] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications A 27 – 24 and A 87 – 27.

Revision[1] of Standard Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 33):[2]

Explanatory Note.—Change the Explanatory Note at the end of these specifications to read as follows:

NOTE.—Allowable pressures and their corresponding allowable temperatures are given in the following table. Higher temperatures with appropriate pressures may be used at the discretion of the designing engineer.

TABLE I.—MAXIMUM SERVICE PRESSURES FOR POWER PIPING AND OIL PIPING AT TEMPERATURES BELOW AND ABOVE 750 F.

Primary Service Pressure Rating at 750 F., lb. per sq. in.	100	300	400	600	900	1500
SERVICE TEMPERATURE, DEG. FAHR.	MAXIMUM SERVICE PRESSURES, LB. PER SQ. IN.					
POWER PIPING AND OIL PIPING						
100	230	500	670	1000	1500	2500
150	220	480	640	960	1440	2400
200	210	465	620	930	1395	2325
250	200	450	600	900	1350	2250
300	190	435	580	870	1305	2175
350	180	420	560	840	1260	2100
400	170	405	540	810	1215	2025
450	160	390	520	780	1170	1950
500	150	375	500	750	1125	1875
550	140	360	480	720	1080	1800
600	130	345	460	690	1035	1725
650	120	330	440	660	990	1650
700	110	315	420	630	950	1575
750	100	300	400	600	900	1500
POWER PIPING						
800	85	250	335	500	750	1250
850	70	200	270	400	600	1000
OIL PIPING						
800	92	275	370	550	830	1380
850	82	245	330	490	740	1230
900	70	210	280	420	630	1050
950	55	165	220	330	495	825
1000	40	120	160	240	360	600

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part I.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 544 (1933); also 1934 Book of A.S.T.M. Tentative Standards, p. 19.

Reference may be made to the dimensional standards for hydraulic pressure ratings and corresponding temperatures formulated by the Sectional Committee on Standardization of Pipe Flanges and Fittings, under the procedure of the American Standards Association, A.S.A. Project B 16 and more specifically to the American Standard for Steel Flanged Fittings and Companion Flanges, B 16e – 1932. Copies of this American Standard are obtainable from the American Standards Association or from the American Society of Mechanical Engineers, 29 West 39th St., New York City.

Revision submitted, June, 1934; Modified, August, 1934.

Revision[1] of Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A.S.T.M. Designation: A 96 – 33):[2]

Section 16.—Change this section to read as follows by the addition of the italicized words, the chemical requirements remaining the same:

16. Bolts and studs shall be equipped with semifinished nuts of American Standard heavy dimensions, chamfered and trimmed. *Nuts shall be made by the cold-punched or hot-forged, cold-trimmed process; nuts cut from drawn or rolled bar stock shall not be permitted.* If washers are used under nuts, they shall be of forged or rolled steel. All nuts and washers shall be free from injurious defects and shall have a workmanlike finish. Nuts shall conform to the chemical requirements for phosphorus and sulfur as follows:

Revision submitted, June, 1934.

Section 17.—Change this section to read as follows by the addition of the italicized words:

17. American National Standard coarse screw threads shall be used, except that no stud ***or bolt*** shall have less than eight threads per inch.

Revision submitted, June, 1934.

Explanatory Note.—Make the same change in the Explanatory Note, appearing at the end of these specifications, as is recommended in the Explanatory Note of Specifications A 95 – 33, above.

Revision[1] of Standard Specifications for Forged or Rolled Steel Pipe Flanges for High-Temperature Service (A.S.T.M. Designation: A 105 – 33):[2]

Class A Flanges.—Delete from these specifications all requirements for Class A flanges. This deletion will require adjustment of the following sections: 1 (*b*), 5 (*a*) and (*b*), 6 (*a*) and (*b*), 9 (*a*) and Explanatory Note 2. In order to avoid the inconsistency of having Classes *B* and *C* referred to with no Class *A*, redesignate the two remaining classes of flanges as Classes I and II.

Revision submitted, June, 1934.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part I.

Explanatory Note.—Make the same change in the Explanatory Note 1, appearing at the end of these specifications, as is recommended in the Explanatory Note of Specifications A 95 – 33, above.

Revision[1] of Standard Specifications for Chilled Cast-Iron Wheels (A.S.T.M. Designation: A 46 – 24):[2]

The Tentative Specifications for Chilled-Tread Cast-Iron Wheels (A 46 – 30 T)[3] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications A 46 – 24.

Revision[1] of Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A.S.T.M. Designation: A 116 – 30):[2]

The Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Wire Fencing (A 116 – 32 T)[4] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications A 116 – 30.

Revision[1] of Standard Specifications for Zinc-Coated (Galvanized) Iron or Steel Barbed Wire (A.S.T.M. Designation: A 121 – 30):[2]

The Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Barbed Wire (A 121 – 32 T)[5] are in effect a tentative revision of and are intended to replace when adopted the present Standard Specifications A 121 – 30.

Revision[1] of Standard Specifications for Wrought-Iron Plates (A.S.T.M. Designation: A 42 – 30):[2]

The Tentative Specifications for Wrought-Iron Plates (A 42 – 34 T)[6] are in effect a tentative revision of and are intended to replace when adopted the present Standard A 42 – 30.

Revision[1] of Standard Specifications for Hollow Rolled Staybolt Iron (A.S.T.M. Designation: A 86 – 30):[2]

Section 11.—Change the center heading, "Permissible Variations in Gage," which precedes this section, to read, "Permissible Variations."

Add the following sentence as Paragraph (*b*), lettering the present section as Paragraph (*a*):

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part I.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 976 (1930); also 1934 Book of A.S.T.M. Tentative Standards, p. 146.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 599 (1932); also 1934 Book of A.S.T.M. Tentative Standards, p. 109.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 606 (1932); also 1934 Book of A.S.T.M. Tentative Standards, p. 106.

[6] See p. 648.

(*b*) The diameter of hole shall be $\frac{3}{16}$ in. within a permissible variation of -0 and $+\frac{1}{32}$ in. A rod $\frac{1}{8}$ in. in diameter shall pass freely through the entire length of the tell-tale hole. The tell-tale hole may be off center $\frac{1}{16}$ in., maximum.

Revision submitted, June, 1934.

Revision[1] of Standard Specifications for Composition Brass or Ounce Metal Sand Castings (A.S.T.M. Designation: B 62 – 28):[2]

Title.—Omit the word "Sand" from the title.

Section 3 (*a*).—Change the table of requirements as to chemical composition to read as follows by the addition of the italicized figures and the omission of those in brackets:

	DESIRED	MINIMUM	MAXIMUM
Copper, per cent	85.00	84.00	86.00
Tin, per cent	5.00	4.00	6.00
Lead, per cent	5.00	4.00	6.00
Zinc, per cent	5.00	4.00	6.00
Iron, per cent	[none]	......	0.25
Nickel, per cent	......	......	*1.00* [0.75]
Phosphorus, per cent	[none]	......	0.05
[Aluminum, per cent]	[none]	......	[none]
[Sulfur, per cent]	......	......	[0.05]
[Antimony, per cent]	......	......	[0.25]
[Total other impurities, per cent]	......	......	[0.15]

Section 5 (*a*).—Change the table of requirements as to tensile properties to read as follows by the addition of the italicized figures and the omission of those in brackets:

Tensile strength, lb. per sq. in.	*30 000* [26 000]
Yield point, lb. per sq. in.	*14 000* [12 000]
Elongation in 2 in., per cent	*20* [15]

Revision submitted, August, 1934.

Revision[1] of Standard Specifications for Steam or Valve Bronze Sand Castings (A.S.T.M. Designation: B 61 – 28):[2]

Title.—Omit the word "Sand" from the title.

Section 3 (*a*).—Change the requirements as to chemical composition from their present form: namely,

	DESIRED	MINIMUM	MAXIMUM
Copper, per cent	88.00	86.00	91.00
Tin, per cent	6.50	6.00	7.00
Lead, per cent	1.50	1.00	2.00
Zinc, per cent	4.00	remainder	remainder
Iron, per cent	......	......	0.15
Nickel, per cent	......	......	0.50
Phosphorus, per cent	......	......	0.05
Aluminum, per cent	none	......	none
Antimony, per cent	......	......	0.25
Sulfur, per cent	......	......	0.05
Total other impurities, in addition to those specified above, per cent	......	......	0.15

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part I.

to read as follows:

Copper, min., per cent	86.5
Tin, per cent	5.5 to 6.5
Lead, per cent	1.5 to 2.0
Zinc, per cent	2 to 5
Iron, max., per cent	0.25
Nickel, max., per cent	1.00
Phosphorus, max., per cent	0.05

Section 5 (a).—Change the table of requirements as to tensile properties to read as follows by the addition of the italicized figures and the omission of those in brackets:

Tensile strength, lb. per sq. in	*34 000* [32 000]
Yield point, lb. per sq. in	16 000
Elongation in 2 in., per cent	*22* [17]

Revision submitted, August, 1934.

Revision[1] of Standard Specifications for Sand Castings of the Alloy: Copper 88 per cent; Tin 8 per cent; Zinc 4 per cent (A.S.T.M. Designation: B 60 - 28):[2]

Title.—Omit the word "Sand" from the title.

Section 1.—Add to the scope clause the following sentence as a new Paragraph (*c*):

(*c*) It is recommended that this alloy shall not be used where castings are subjected to a temperature exceeding 260 C. (500 F.).

Section 3 (a).—Change the table of requirements as to chemical composition to read as follows by the addition of the italicized figures and the omission of those in brackets:

	DESIRED	MINIMUM	MAXIMUM
Copper, per cent	88.00	86.00	89.00
Tin, per cent	8.00	7.50	11.00
Lead, per cent	none	......	0.30
Zinc, per cent	4.00	1.50	4.50
Iron, per cent	[none]	......	*0.25* [0.10]
Nickel, per cent	......	......	*1.00* [0.50]
Phosphorus, per cent	......	......	0.05
[Aluminum, per cent]	[none]	......	[none]
[Sulfur, per cent]	[none]	......	[0.05]
[Antimony, per cent]	[none]	......	[0.25]
[Total other impurities, per cent]	[none]	......	[0.15]

Section 5 (a).—Change the table of requirements as to tensile properties to read as follows by the addition of the italicized figures and the omission of those in brackets:

Tensile strength, lb. per sq. in	*38 000* [35 000]
Yield point, lb. per sq. in	*16 000* [15 000]
Elongation in 2 in., per cent	*22* [15]

Revision submitted, August, 1934.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part I.

Revision[1] of Standard Methods of Chemical Analysis of Manganese Bronze (A.S.T.M. Designation: B 27 – 19):[2]

Under the Determination of Manganese by the Persulfate Method, change the description under Method from its present form: namely,

> In a 250-cc. Erlenmeyer flask dissolve 1 g. of bronze in 24 cc. of the "solution for dissolving." Allow to stand on a steam bath or hot plate until entirely dissolved, and until the oxides of nitrogen are expelled. Add 15 cc. of $AgNO_3$ solution and 20 cc. of ammonium persulfate and leave on the steam bath until the solution has developed a full permanganate color and no bubbles can be seen to come off when the flask is given a whirling motion. Cool to below 25° C. in running water, and add 50 cc. of cold water. Titrate with standard sodium-arsenite solution to the disappearance of the pink color.

to read as follows:

> Adjust the size of sample to the expected percentage so that the portion taken does not contain more than 0.002 g. manganese. Place it in a 250-cc. Erlenmeyer flask with 24 cc. of the "solution for dissolving" and heat until solution is complete. Boil until oxides of nitrogen are expelled. Dilute to 100 cc. with boiling-hot water, add 20 cc. of $AgNO_3$ solution and 30 cc. of the persulfate solution, then remove to a moderately warm place to stand for a few minutes for complete development of the permanganic acid. Cool to below 25° C., and titrate with the standard arsenite solution to the disappearance of the pink color.

Revision submitted, June, 1928.

Revision[1] of Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings (A.S.T.M. Designation: B 45 – 27):[2]

The Tentative Method of Determination of Phosphorus in Copper-Base Alloys in Ingot Form for Sand Castings (B 45 – 33 T)[3] is in effect a tentative revision of and is intended when adopted to be incorporated in the present Standard Methods B 45 – 27.

Revision[1] of Standard Specifications for Quicklime for Structural Purposes (A.S.T.M. Designation: C 5 – 26):[4]

The Tentative Specifications for Quicklime for Structural Purposes (C 5 – 34 T)[5] are in effect a tentative revision of and are intended to replace when adopted the present Standard C 5 – 26.

Revision[1] of Standard Specifications for Hydrated Lime for Structural Purposes (A.S.T.M. Designation: C 6 – 31):[2]

The Tentative Specifications for Hydrated Lime for Structural Purposes (C 6 – 34 T)[6] are in effect a tentative revision of and are intended to replace when adopted the present Standard C 6 – 31.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part I.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part I, p. 638 (1933); also 1934 Book of A.S.T.M. Tentative Standards, p. 229.

[4] 1933 Book of A.S.T.M. Standards, Part II.

[5] See p. 749.

[6] See p. 752.

Revision[1] of Standard Specifications for Cement-Concrete Sewer Pipe (A.S.T.M. Designation: C 14 – 24):[2]

Section 1.—Add the following footnote:

Caution.—The consumer or purchaser is cautioned against using cement-concrete pipe where the sewage shows an acid reaction.

Revision submitted, June, 1924.

The Tentative Specifications for Non-Reinforced Concrete Sewer Pipe (C 14 – 34 T)[3] are in effect a tentative revision of and are intended to replace when adopted the present Standard C 14 – 24.

Revision[1] of Standard Specifications for Clay Fire Brick for Malleable Furnaces with Removable Bungs and for Annealing Ovens (A.S.T.M. Designation: C 63 – 28):[2]

These specifications contain requirements for softening point of clay refractories. Since this property of fire clay, fire brick and silica cement is now known as pyrometric cone equivalent it is proposed that the term "softening point" as it appears in these specifications be changed to read "pyrometric cone equivalent."

Revision submitted, June, 1933.

Revision[1] of Standard Specifications for Clay Fire Brick for Stationary Boiler Service (A.S.T.M. Designation: C 64 – 28):[2]

Make the same change in these specifications as is recommended in Specifications C 63 – 28 above.

Revision submitted, June, 1933.

Revision[1] of Standard Specifications for Clay Fire Brick for Marine Boiler Service (A.S.T.M. Designation: C 65 – 28):[2]

Make the same change in these specifications as is recommended in Specifications C 63 – 28 above.

Revision submitted, June, 1933.

Revision[1] of Standard Methods of Ultimate Chemical Analysis of Refractory Materials, Including Chrome Ores and Chrome Brick (A.S.T.M. Designation: C 18 – 21):[2]

The Tentative Method of Chemical Analysis of Magnesite Refractories (C 18 – 34 T)[4] is intended to be included, when adopted, with the present Standard C 18 – 21. When this combination of the procedures is made the title of the methods will be changed to read: "Standard Methods of Ultimate Chemical Analysis of Refractory Materials."

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part II.

[3] See p. 809.

[4] See p. 784.

Revision[1] of Standard Method of Test for Refractory Materials Under Load at High Temperatures (A.S.T.M. Designation: C 16 - 20):[2]

Section 2 (*d*).—Add the following as a second paragraph of the present Paragraph (*d*):

If the optical pyrometer is used, observations shall be made by sighting into a refractory tube having a closed end in the same relative position to the test specimen as that specified for the thermocouple.

Revision submitted, June, 1933.

Revision[1] of Standard Method of Test for Softening Point of Fire-Clay Brick (A.S.T.M. Designation: C 24 - 33):[2]

Title.—Change the title of this method to read as follows, by the addition of the italicized words and the omission of those in brackets:

Standard Method of Test for [Softening Point] *Determining the Pyrometric Cone Equivalent* of Fire-Clay *and Fire* Brick.

Revision submitted, June, 1931.

It is also proposed that the term "Orton cones" as it appears in this method be changed to read "Standard Pyrometric Cones."

Revision submitted, June, 1933.

Section 1.—Change the scope of this method from its present form: namely,

1. The object of this test is to determine the softening point of fire-clay brick, by comparison of test cones with standard Orton pyrometric cones heated in a suitable furnace.

to read as follows:

1. This method is intended for determining the pyrometric cone equivalent of fire clay, fire brick, silica cement and ground fire clay by comparison of test cones with Standard Pyrometric Cones under the conditions herein prescribed.

Revision submitted, June, 1931.

Section 3 (*a*).—Change the description of the test cones from its present form: namely,

3. (*a*) The sample thus prepared shall be thoroughly mixed and, after the addition of sufficient dextrine or glue and water, shall be formed into test cones in a metal mold in the shape of tetrahedrons measuring 5 mm. ($\frac{3}{16}$ in.) on the sides at the base and 25 mm. (1 in.) high.

to read as follows:

3. (*a*) The dried sample shall be thoroughly mixed and after the addition of sufficient dextrine, glue, gum tragacanth or other alkali-free organic binder and water, shall be formed into test cones in a metal mold in the shape of tetrahedrons 8 mm. ($\frac{5}{16}$ in.) on the sides at the base and 25 mm. (1 in.) in height.

Revision submitted, June, 1931.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part II.

Appendix.—Add the following cone temperature table as an Appendix to these methods:

The Temperature corresponding with the end points of those Standard Pyrometric Cones, which are used in connection with refractories, are as follows:

Cone	End Point Deg. Cent.	End Point Deg. Fahr.	Cone	End Point Deg. Cent.	End Point Deg. Fahr.
No. 15	1435	2615	No. 29	1640	2984
No. 16	1465	2669	No. 30	1650	3002
No. 17	1475	2687	No. 31	1680	3056
No. 18	1490	2714	No. 32	1700	3092
No. 19	1520	2768	No. 33	1745	3173
No. 20	1530	2786	No. 34	1760	3200
No. 23	1580	2876	No. 35	1785	3245
No. 26	1595	2903	No. 36	1810	3290
No. 27	1605	2921	No. 37	1820	3308
No. 28	1615	2939	No. 38	1835	3335

NOTE.—These temperatures, which were determined by Fairchild and Peters[a] for a heating rate of 150° C. per hour for cones Nos. 15 to 20, and of 100° C. per hour for cones Nos. 23 to 38, other conditions being the same as specified, apply satisfactorily for all the conditions of this test method, but do not apply to conditions of the commercial firing and use of refractory materials.

---

[a] **Fairchild and Peters, "Characteristics of Pyrometric Cones,"** ***Journal,*** **Am. Ceramic Soc., Vol. 9, No. 11, p. 700, November, 1926.**

Revision submitted, June, 1931.

Section 5.—Add to the table of heating rates following Paragraph (*a*) the following requirements for cones Nos. 36, 37 and 38, not heretofore provided for:

Time interval to cone 36	**10 minutes**
" " " " 37	**4 "**
" " " " 38	**6 "**

Revision submitted, June, 1932.

Section 6.—Change the expression, "softening point" as it appears in this section to read "Pyrometric Cone Equivalent."

Revision submitted, June, 1933.

Revision[1] of Standard Definitions for Clay Refractories (A.S.T.M. Designation: C 27 - 28):[2]

These definitions contain requirements for softening point of clay refractories. Since this property of fire clay, fire brick and silica cement is now known as pyrometric cone equivalent it is proposed that the term "softening point" as it appears in these definitions be changed to read "Pyrometric Cone Equivalent."

Revision submitted, June, 1933.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part II.

Revision[1] of Standard Definitions of Terms Relating to Refractories (A.S.T.M. Designation: C 71 – 31):[2]

Several definitions of terms published under the title "Tentative Definitions of Terms Relating to Refractories (C 71 – 34 T)"[3] are intended to be added when adopted to the present Standard Definitions C 71 – 31.

Revision[1] of Standard Definitions of Terms Relating to the Gypsum Industry (A.S.T.M. Designation: C 11 – 28):[2]

Several definitions of terms published under the title "Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 – 31 T)"[4] are intended to be added when adopted to the present Standard Definitions C 11 – 28.

Revision[1] of Standard Definition of the Term Sand (A.S.T.M. Designation: C 58 – 28):[2]

The Tentative Definition of the Term Aggregate (C 58 – 28 T)[5] is intended to be included, when adopted, with the present Standard Definition C 58 – 28.

Revision[1] of Standard Specifications for Amyl Acetate (Synthetic) (A.S.T.M. Designation: D 318 – 33):[2]

The Tentative Specifications for Amyl Acetate (from Fusel Oil) (85 to 88 per cent Grade) (D 318 – 34 T)[6] are intended to be included, when adopted, with the present Standard D 318 – 33.

Revision[1] of Standard Methods of Routine Analysis of Dry Red Lead (A.S.T.M. Designation: D 49 – 33):[2]

Section 6.—Change the procedure for determining Total Lead and Insoluble Matter to read as follows:

6. (*a*) Treat 1 g. of the sample with 15 cc. of HNO_3 (1:1) and sufficient H_2O_2 to dissolve all PbO_2 on warming. If any insoluble matter is present, add 25 cc. of water, boil, filter and wash with hot water. The insoluble matter contains free SiO_2 and should be examined for $BaSO_4$ and silicates, if appreciable. To the original solution or filtrate from insoluble, add 20 cc. of concentrated H_2SO_4 and evaporate to SO_3 fumes; cool, add 150 cc. of water, and 150 cc. of 95 per cent ethyl alcohol, let stand *cold* 2 hr., filter on a Gooch crucible, wash with 95 per cent alcohol, dry at 105 to 110 C. and weigh as $PbSO_4$. Calculate to PbO. Red lead is rarely adulterated, but should sample contain soluble barium compounds, the $PbSO_4$ obtained above will contain $BaSO_4$. In this

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part II.

[3] See p. 806.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part I, p. 749 (1931); also 1934 Book of A.S.T.M. Tentative Standards, p. 317.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 835 (1928); also 1934 Book of A.S.T.M. Tentative Standards, p. 491.

[6] See p. 878.

case, precipitate the lead as sulfide from a slightly acid (HCl) solution, dissolve the PbS in hot dilute HNO_3 and determine the lead as sulfate or chromate. If sample contains significant amounts of calcium or magnesium, boil the HNO_3–H_2O_2 solution until all the lead is converted into nitrate and then determine the lead as $PbCrO_4$.

(*b*) If soluble barium, calcium or magnesium are to be determined, precipitate the lead as sulfide from a slightly acid solution (HCl), dissolve the PbS in hot dilute HNO_3 and determine the lead as sulfate. Boil the filtrate from the PbS to expel H_2S, add a little bromine water to oxidize iron (if present) boil to expel bromine and precipitate the barium with a few cubic centimeters of H_2SO_4 (1:3). Filter and weigh as $BaSO_4$. Calculate to BaO or $BaCO_3$. To the filtrate from the $BaSO_4$, add NH_4OH in slight excess, filter off any precipitate of $Fe(OH)_3 + Al(OH)_3$; wash with hot water. Manganese, if present, can be precipitated by adding bromine and NH_4OH and warming; filter, wash with hot water, ignite and weigh as Mn_3O_4. Unite all the filtrates, make slightly acid with acetic acid, heat to boiling and pass H_2S into the hot solution till saturated (20 to 30 minutes); add 5 g. of NH_4Cl and let stand 5 hr.; filter off any ZnS, wash with H_2S water, dissolve the ZnS in hot dilute HCl and determine the zinc by titration with $K_4Fe(CN)_6$. Or, boil off the H_2S, filter out any separated sulfur and determine the zinc as $Zn_2P_2O_7$. Calcium may be determined in the filtrate from the ZnS by expelling H_2S and then adding NH_4OH and ammonium oxalate in the usual manner. Titrate with $KMnO_4$. In the filtrate from calcium determine magnesium in the usual manner by precipitating with sodium-phosphate solution, finally weighing as $Mg_2P_2O_7$.

Revision submitted, June, 1934.

Revision[1] of Standard Methods of Routine Analysis of White Linseed Oil Paints (A.S.T.M. Designation: D 215 – 29):[2]

Testing Non-Volatile Vehicle.—At the end of Section *A*, *Preparation of Fatty Acids*, add the following new paragraph:

Instead of the preceding method the following procedure may be used, especially with samples that give trouble by the former: To about 50 g. of paint in a porcelain casserole, add 30 cc. of aqueous 30 per cent NaOH and 125 cc. of ethyl alcohol, mix and evaporate on steam bath until residue is dry. Transfer to a 400-cc. beaker and boil with 200 cc. of water, add H_2SO_4 (sp. gr. 1.2) (25 cc. in excess), boil, stir, filter through large coarse paper, and drain. Scrape mass into a flask, shake violently with ether, centrifuge, decant into a separatory funnel, and wash with small amounts of water until free of H_2SO_4. Transfer ether solution to dry flask and leave over about 40 g. of anhydrous sodium sulfate until ether layer is clear. Decant the clear solution through filter paper into a dry 100-cc. flask. Pass a rapid current of dry air into the mouth of the flask and heat to a temperature below 75° C. on a dry hot plate until the ether is entirely removed. The fatty acids prepared as above should be kept in a stoppered flask and examined at once.

Revision submitted, June, 1932.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part II.

Under Section (2) Mixed or Composite Pigments, change the procedure for determining *Insoluble Matter* to read as follows:

Insoluble Matter.—Moisten 1 g. of the sample with a few drops of alcohol, cover, add 40 cc. of HCl (1:1), boil gently for 5 to 10 minutes. Wash off cover, evaporate to dryness, and heat at about 150 C. for 30 minutes to 1 hr. to dehydrate the residue. Moisten the residue with 4 cc. of concentrated HCl, allow to stand a few minutes, dilute with 100 cc. of hot water, boil a few minutes, filter hot through paper, wash with hot water (till washings give no test for lead and chlorine). Ignite the paper and residue in a platinum or porcelain crucible, cool, and weigh total insoluble matter (Note 5). (The insoluble matter may be filtered off on a Gooch crucible, washed with hot water, dried at 105 C., cooled, and weighed; then ignited, cooled, and weighed, when it is desired to get the loss on ignition (combined water, organic matter, etc.) of same, or the insoluble matter is not to be further examined.) If the sample contains titanium pigment, practically all of the TiO_2 will be found in the insoluble matter along with $BaSO_4$ and siliceous matter. Should an examination of the insoluble matter be necessary, it is advisable to remove the TiO_2 before proceeding further. The TiO_2 may be removed (or determined on a separate portion) by the method described in Section 9 of the Standard Methods of Routine Analysis of Titanium Pigments (A.S.T.M. Designation: D 186) of the American Society for Testing Materials.[1] After removing the TiO_2, the residue containing siliceous matter and $BaSO_4$ may be ignited to remove the filter. To determine $BaSO_4$, mix the ignited insoluble matter with about ten times its weight of anhydrous sodium carbonate (grinding the mixture in an agate mortar if necessary) and fuse in a covered platinum crucible, heating about 1 hr. Let cool, place crucible and cover in a 200-cc. glazed porcelain casserole,[a] add about 100 cc. of water and heat until the mass is disintegrated. Filter on paper into a 300-cc. glazed porcelain casserole (leaving crucible and cover in the original casserole) and wash the casserole and filter thoroughly with a hot solution of Na_2CO_3 (1 per cent). Place the casserole containing the crucible and cover under the funnel, pierce the filter with a glass rod, and wash the residue into the original casserole by means of a jet of hot water. Wash the paper with hot HCl (1:1) and then with hot water. Remove the crucible and cover. Evaporate the HCl solution to dryness, and heat at about 150 C. for 30 minutes to 1 hr.; moisten the residue with about 10 cc. of concentrated HCl, dilute with 100 cc. of hot water, boil a few minutes, filter hot through paper and wash thoroughly with hot water. Dilute the filtrate to a volume of 300 cc., bring to boiling and add, drop by drop, 5 cc. of H_2SO_4 (1:4). Allow to stand in a warm place an hour or so, filter on a weighed Gooch crucible, wash with hot water, ignite, cool and weigh as $BaSO_4$. Subtract the sum of the percentages of $BaSO_4$ and TiO_2 from the percentage of total insoluble matter and report the result as the percentage of insoluble siliceous matter (Note 6).

To determine silica, acidify the filtrate from the $BaCO_3$ filtration with HCl, boil to expel CO_2, evaporate to dryness, bake to dehydrate the silica, moisten with HCl, dilute with 100 cc. of hot water, boil and filter through the same paper as was used to recover silica from the $BaCO_3$ portion. Wash thoroughly with hot water and proceed as in a silicate analysis.

---

[a] A casserole is preferable to a beaker as silica is dissolved from glass when in long contact with a strong sodium carbonate solution.

[1] 1933 Book of A.S.T.M. Standards, Part II, p. 577.

If it is desired to look for magnesium, combine this last filtrate with the filtrate from the final $BaSO_4$ separation and test for Al_2O_3 and MgO in the usual way. To recover MgO that may have dissolved in the procedure for the elimination of the TiO_2, make the filtrate containing the TiO_2 just alkaline with NH_4OH, bring to boiling, filter and wash. The filtrate may be tested for MgO. Any Al_2O_3 present will be precipitated along with the TiO_2. To recover this, ignite and weigh as TiO_2 and Al_2O_3. Deduct for TiO_2 present in the sample; the difference is Al_2O_3.

Revision submitted, June, 1932; Modified, June, 1934.

Also under (2) Mixed or Composite Pigments, in the second paragraph under "Total Lead (Antimony)," change the seventh sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

[Moisten the residue with a few drops of HCl,] *To the residue add sufficient concentrated HCl to dissolve the $PbSO_4$ (with pigments containing considerable amounts of $PbSO_4$, it may be necessary to add 15 to 20 cc. of concentrated HCl)*, add about 50 cc. of hot water, boil a few minutes, filter hot through paper, and wash with hot water until washings give no test for lead.

Revision submitted, June, 1932.

In the procedure for *Total Zinc* under B. Quantitative Analysis, (2) Mixed or Composite Pigments, change Paragraph (*d*) to read as follows:

(*d*) With pigments containing ZnO and ZnS, the ZnO may be determined as follows: Weigh accurately 1 g. of the pigment, transfer to a 250-cc. beaker, moisten with alcohol, add about 100 cc. of 1 to 3 per cent acetic acid, stir vigorously but do not heat, cover, and let stand for 18 hours, stirring once every 5 minutes for the first half hour. Filter, wash with 1 to 3 per cent acetic acid followed by water until the washings give no test for zinc with $K_4Fe(CN)_6$ solution. Dilute the clear filtrate to about 200 cc. with water, add 30 cc. of HCl (1:2), and a small piece of litmus paper; add strong NH_4OH until slightly alkaline, render just acid with HCl, then add 3 cc. of concentrated HCl, heat nearly to boiling, and titrate with $K_4Fe(CN)_6$ solution as above. Calculate this result to Zn, subtract from total Zn, and calculate the difference to ZnS. (Any $ZnCO_3$ or $ZnSO_4$ is included in the ZnO.)

Revision submitted, June, 1932.

In the last sentence of the fourth paragraph at the end of the methods change the footnote to the procedure of the Federal Specifications Board to read as follows:

Federal Specifications Board, Federal Specification TT-P-36 for Paints; Lead-Zinc Base, Ready-Mixed and Semipaste, White and Tinted, p. 2: "The total lead dissolved in dilute acetic acid and hot ammonium acetate, weighed as lead sulfate, and this weight multiplied by the factor 0.883 shall be considered white lead. It is not possible to determine the amount of lead carbonate and lead sulfate when carbonates or sulfates of other metals, such as calcium, are present. Also neither basic lead carbonate nor basic lead sulfate are definite compounds. The factor to convert $PbSO_4$ to $(PbCO_3)_2Pb(OH)_2$ is 0.854, to convert $PbSO_4$ to $PbSO_4PbO$ is 0.868, and to convert $PbSO_4$ to $(PbSO_4)_2PbO$ is 0.913. The arbitrary factor used under this specification is the mean of the largest and smallest of these factors."

Revision submitted, June, 1932.

Revision[1] of Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green (A.S.T.M. Designation: D 126 – 27):[2]

Under General Methods add the following paragraph as a new Section 1, renumbering the present sections accordingly:

1. *Treatment of Sample.*—Dry pigments if lumpy or not finely ground shall be ground to a fine powder for analysis. Large samples may be thoroughly mixed and a representative portion taken and powdered, if lumpy or not finely ground. The sample in all cases shall be thoroughly mixed before taking portions for analysis. Extracted pigments shall be ground to a fine powder, passed through a No. 80 sieve to remove any skins, and thoroughly mixed. The weighed portions of extracted pigments should be moistened with a little alcohol before adding reagents for analysis. All samples shall be preserved in stoppered bottles or containers.

Revision submitted, June, 1932.

Section 7.—Change the ninth sentence to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

[Render an aliquot portion acid with H_2SO_4, boil to expel any free oxygen, cool,] *Boil an aliquot portion vigorously for 10 to 15 minutes to expel H_2O_2, cool, acidify with H_2SO_4,* add an excess of standard $(NH_4)_2Fe(SO_4)_2.6H_2O$ solution and titrate back with 0.1 N $K_2Cr_2O_7$ solution, using $K_3Fe(CN)_6$ as outside indicator.

Revision submitted, June, 1932.

Also in this section change the second from the last sentence in the first paragraph to read as follows by the addition of the italicized words and the omission of those in brackets:

If iron or aluminum are not to be determined or are present in negligible amounts, the first NH_4OH precipitate may be dissolved in dilute HCl, oxidized with Na_2O_2, [acidified with H_2SO_4, boiled,] *boiled vigorously for 10 to 15 minutes to expel H_2O_2, cooled, acidified with H_2SO_4,* and CrO_3 determined volumetrically.

Revision submitted, June, 1932.

Section 11.—In the third sentence change "20 cc." to read "25 cc."

Revision submitted, June, 1932.

Section 22.—Change from its present form: namely,

22. Make the test for water-soluble matter in accordance with Section 11.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part II.

to read as follows:

22. Transfer 2.5 g. of the pigment to a graduated 250-cc. flask, fill to the mark with water and stopper. Shake vigorously and let stand at room temperature for not less than 15 hours, shaking vigorously from time to time. Then let settle, filter through a dry filter paper and discard the first 25 cc. of the filtrate. Transfer 100 cc. of the clear filtrate to a weighed dish, evaporate to dryness on a steam bath, dry for one hour in an oven at 105 to 110° C., cool and weigh. Calculate the percentage of water-soluble matter.

Revision submitted, June, 1932.

Section 38.—Change to read as follows by the addition of the italicized words:

38. On a separate sample determine the sulfate directly with Na_2CO_3 as in the preceding paragraph, without any preliminary treatment with bromine water *or nitric acid.*

Revision submitted, June, 1932.

Section 53.—Change the reference from "Section 11" to read "Section 22."

Revision submitted, June, 1932.

New Methods.—Add the following Methods of Analysis of Chrome Oxide Green as Sections 55 to 57:

METHODS OF ANALYSIS OF CHROME OXIDE GREEN

Chrome oxide green is practically pure sesquioxide of chromium (Cr_2O_3) without any admixture.

Moisture

55. Determine moisture in accordance with Section 45.

Water-Soluble Matter

56. Determine water-soluble matter in accordance with Section 11.

Total Chromium

57. (*a*) *Standard Ferrous Solution.*—Dissolve 39.25 g. of ferrous ammonium sulfate crystals in 950 cc. of distilled water and add 50 cc. of H_2SO_4 (sp. gr. 1.84).

(*b*) *Decinormal Potassium Permanganate Solution.*—Dissolve 3.2 g. of pure $KMnO_4$ and 1 liter of distilled water, let stand 8 to 14 days, siphon off the clear solution (or filter through asbestos), and standardize as follows: In a 400-cc. beaker dissolve 0.20 to 0.25 g. (accurately weighed) of pure potassium pyro chromate, $K_2Cr_2O_7$, crystals in about 300 cc. of water and add 20 cc. of H_2SO_4 (1:1). Add a measured excess of 0.1 *N* $FeSO_4$ solution and titrate back with the $KMnO_4$ solution which is being standardized. Now take the same volume of $FeSO_4$ solution and dilute to 300 cc. and titrate with the $KMnO_4$ solution. The difference between the two titrations represents the ferrous sulfate that was oxidized by the dichromate in terms of cubic centimeter readings of $KMnO_4$. The weight of pure $K_2Cr_2O_7$ divided by the cubic centimeter readings of $KMnO_4$ (by difference) gives the grams of $K_2Cr_2O_7$ equivalent to 1 cc. of $KMnO_4$. One cubic centimeter of the $KMnO_4$ solution should be equal to about 0.00173 g. of chromium.

58. *Procedure.*—Mix thoroughly about 0.25 g. (accurately weighed) of the sample with approximately 5 g. of sodium peroxide (containing at least 90 per cent Na_2O_2) in a 30-cc. pure iron crucible (ordinary iron crucibles may contain some chromium and manganese) and fuse carefully over a gas flame. Five minutes fusion at a low red heat after the mass has melted will insure complete decomposition. Allow the crucible to partly cool, and while tightly covered, tap on an iron plate to loosen the fusion in a solid cake. Place the cake in a covered beaker and dissolve with 200 cc. of warm water. Rinse the crucible and cover with warm water, adding to the main portion. Add approximately 1 g. of sodium peroxide and boil the solution vigorously for 10 minutes to destroy excess peroxide. If excess peroxide is not destroyed, some of the chromium will be reduced when the solution is acidified. Cool and acidify with sulfuric acid (50 cc., 1:1 sulfuric acid). A clear solution with a few scales of magnetic oxide should result. Immediately cool again, add 5 cc. of phosphoric acid (sirup, sp. gr. 1.7), transfer to an 800-cc. beaker and dilute with cold water to 500 cc. Add an accurately measured excess (about 100 cc.) of approximately 0.1 *N* ferrous ammonium sulfate to the solution while stirring. When reduction is complete a deep pure green color should develop, and a drop of the liquid when tested with a drop of dilute potassium ferricyanide solution should give a blue color. Set the beaker about ½ in. above a white tile to secure good light. Determine the excess of ferrous sulfate by titration with a standard solution (approximately 0.1 *N*) of potassium permanganate. Take the first faint permanent darkening of the clear green color as the end point. Addition of more permanganate increases the depth of the color which finally becomes purple. The end point is quite sharp and well defined, but requires some practice. In exactly the same manner carry through a blank determination, starting with a peroxide fusion. Finally, add the exact volume of ferrous solution as was used in the determination and titrate back with the $KMnO_4$ solution. The difference between the volumes required in the two titrations represents the chromium in the sample and the percentage is found by multiplying this value by 400 times the chromium titre of the $KMnO_4$ solution.

Revision submitted, June, 1932; Modified, June, 1934.

Revision[1] of Standard Definitions of Terms Relating to Paint Specifications (A.S.T.M. Designation: D 16 - 24):[2]

Add the following three new definitions of terms:

Screen (*Sieve*).—A plate or sheet or a woven cloth, or other device, with regularly spaced apertures of uniform size, mounted in a suitable frame or holder, for use in separating material according to size.

NOTE 1.—The shape and spacing of apertures, size of wires or threads, thickness of plate or sheet, allowable variations and similar properties should be taken care of in specifications.

NOTE 2.—In mechanical analysis testing work, when not otherwise specified, the term "sieve" shall apply to an apparatus in which the apertures are rectangular, and the term "screen" shall apply to an apparatus in which the apertures are circular.

---

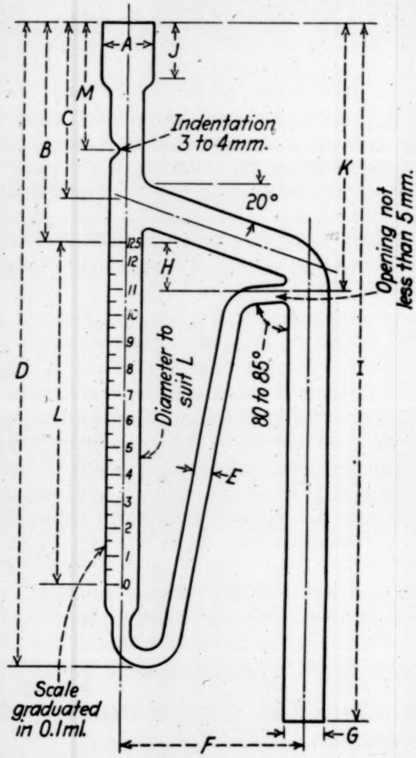
[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part II.

Toughness.—That quality of a material which may be measured by the maximum impact which it will withstand without rupture.

Elasticity.—In the case of paint or varnish, that property which allows a film to follow, without rupture, changes in the extent and form of the surface to which it is applied.

Revision submitted, June, 1925; Modified, June, 1928.


A
J
M
C
B
Indentation 3 to 4mm.
20°
K
Opening not less than 5mm.
H
12.5
12
11
10
9
8
7
6
5
4
3
2
1
0
Diameter to suit L
80 to 85°
D
L
E
I
Scale graduated in 0.1ml.
F
G

A	18 to 20 mm., inside diameter	*H*	15 to 20 mm.
B	85 to 90 mm.	*I*	270 to 290 mm.
C	70 to 75 mm.	*J*	25 to 30 mm.
D	240 to 260 mm.	*K*	100 to 110 mm.
E	4 to 5 mm., inside diameter	*L*	125 to 138 mm.
F	65 to 75 mm.	*M*	40 to 50 mm.
G	11 to 15 mm., inside diameter		

FIG. 1.—A.S.T.M. Dilution Trap for Testing Crankcase Oils.

Revision[1] of Standard Method of Test for Dilution of Crankcase Oils (A.S.T.M. Designation: D 322 – 33):[2]

Dilution Trap.—For convenience in manufacture of the dilution trap change the dimensional requirements to conform to those shown in the accompanying Fig. 1.

Revision submitted, June, 1934.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part II.

Revision[1] of Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86 – 30):[2]

Section 8 (d).—Make the footnote referred to in this paragraph a note to appear after Paragraph (*d*) and change it to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

NOTE.—For products having end points not higher than 482 F. (250 C.) or initial boiling points not higher than 212 F. (100 C.), the Low-Distillation Thermometer shall be used; for [all other] products *having end points higher than 482 F. (250 C.) and initial boiling points higher than 212 F. (100 C.)* the High-Distillation Thermometer shall be used.

Revision submitted, June, 1934.

Revision[1] of Standard Method of Test for Precipitation Number of Lubricating Oils (A.S.T.M. Designation: D 91 – 33):[2]

Section 4.—Between the present third and fourth sentences of this section add a new sentence to read as follows:

Air-free distilled water at 20 C. (68 F.) shall be used for the calibration of tubes.

Revision submitted, June, 1934.

Revision[1] of Standard Method of Test for Water and Sediment in Petroleum Products by Means of Centrifuge (A.S.T.M. Designation: D 96 – 30):[2]

Section 4.—Make the same change in this section as recommended in Section 4 of Method D 91 – 33, above.

Revision submitted, June, 1934.

Revision[1] of Standard Specifications for Broken Slag for Waterbound Base and Wearing Course (A.S.T.M. Designation: D 65 – 23):[2]

Section 4.—Omit this section, reading as follows, renumbering the subsequent sections accordingly:

4. The percentage of wear shall be not more than 12.0 per cent.

Revision submitted, June, 1924.

Section 6.—Change the last line of this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

[Retained on] *Passing* 2½-in. screen . . . not [less] *more* than [85] *15* per cent.

Revision submitted, June, 1924.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part II.

Section 7 (b).—Omit this paragraph which refers to the method for determining the percentage of wear.

Revision submitted, June, 1924.

Revision[1] of Standard Specifications for Shovel-Run or Crusher-Run Broken Slag for Waterbound Base (A.S.T.M. Designation: D 66 – 23):[2]

Section 4.—Omit this section, reading as follows, renumbering the subsequent sections accordingly:

4. The percentage of wear shall be not more than 15.0 per cent.

Revision submitted, June, 1924.

Section 6 (b).—Omit this paragraph which refers to the method for determining the percentage of wear.

Revision submitted, June, 1924.

Revision[1] of Standard Specifications for Block for Granite Block Pavements (A.S.T.M. Designation: D 59 – 26):[2]

Section 3 (a).—Change to read as follows by the addition of the italicized words:

3. (*a*) The percentage of wear and the French coefficient of wear shall be determined in accordance with the Standard Method of Test for Abrasion of Rock (A.S.T.M. Designation: D 2) of the American Society for Testing Materials, *except that the sample shall be prepared by use of a press and the fragments shall be as uniform and as nearly cubical as practicable.*

Revision submitted, June, 1929.

Revision[1] of Standard Specifications for Block for Recut Granite Block Pavements (A.S.T.M. Designation: D 131 – 23):[2]

Section 3 (a).—Make the same change in this section as recommended in Section 3 (*a*) of Specifications D 59 – 26 above.

Revision submitted, June, 1929.

Revision[1] of Standard Specifications for Block for Durax Granite Pavements (A.S.T.M. Designation: D 132 – 23):[2]

Section 3 (a).—Make the same change in this section as recommended in Section 3 (*a*) of Specifications D 59 – 26 above.

Revision submitted, June, 1929

Revision[1] of Standard Specifications for Asbestos Yarns (A.S.T.M. Designation: D 299 – 33):[2]

The Tentative Specifications for Asbestos Yarns (D 299 – 34 T)[3] are in effect a tentative revision of and are intended to replace when adopted the present Standard D 299 – 33.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part II.

[3] See p. 1172.

Revision[1] of Standard Specifications for Chafer Tire Fabrics (A.S.T.M. Designation: D 316 - 34):[2]

Section 1.—Change this section to read as follows by the addition of the italicized words and figures:

> 1. These specifications cover commercial 8, 9, 12 and 14-oz. ***plied yarn and*** *8.25, 11.65 and 14-oz.* ***single yarn*** chafer tire fabrics made of carded American cotton of the following constructions:

Add the following to the present tabulation of constructions which follows Section 1:

8.25 oz	single yarn warp and filling	clean white cotton, no waste
11.65 oz	single yarn warp and filling	clean white cotton, no waste
14.00 oz	single yarn warp and filling	clean white cotton, no waste

Table I.—Add to Table I the following requirements covering 8.25, 11.65 and 14-oz. single yarn chafer tire fabrics:

		8.25-oz. Single Yarn			11.65-oz. Single Yarn			14.00-oz. Single Yarn		
		Std.	Min.	Max.	Std.	Min.	Max.	Std.	Min.	Max.
Width, in		60	59.5	60.5	60	59.5	60.5	60	59.5	60.5
Weight, oz. per sq. yd		8.25	8.0	8.5	11.65	11.35	11.95	14.0	13.60	14.4
Count	Warp	32.0	31.3	32.7	32.0	31.3	32.7	23.0	22.5	23.5
	Filling	28.0	26.9	29.1	28.0	26.9	29.1	23.0	22.1	23.9
Thickness (Gage), in		0.0290	0.0273	0.0307	0.0310	0.0295	0.0325	0.0390	0.0370	0.0410
Tensile Strength,[a] lb. Grab Test, Conditioned[b]	Warp	....	95	....	....	145	....	....	160	....
	Filling	....	95	....	....	155	....	....	170	....
Crimp, per cent	Warp	16.0	14.4	17.6	16.0	14.4	17.6	16.0	14.4	17.6
	Filling	9.0	7.2	10.8	9.0	7.2	10.8	9.0	7.2	10.8

[a] Tensile strength values are based on tests made on a 400 to 800-lb. capacity horizontal testing machine of inclination balance type.

[b] Preferred Method, in standard condition or corrected to standard moisture regain (6.5 per cent).

Revision submitted, August, 1934.

Revision[1] of Standard Specifications for Tolerances and Test Methods for Certain Light and Medium Cotton Fabrics (A.S.T.M. Designation: D 274 - 34):[2]

Tear Resistance Test.—Add the following new tear resistance test procedure as a new Section 8, renumbering the present Sections 8 to 15, accordingly:

Tear Resistance

8. (*a*) *Preferred Method.*—A specimen 3 in. in width and 6 in. in length shall be selected for test. An isosceles trapezoid having an altitude of 3 in. and with bases 1 in. and 4 in. in length, respectively, shall then be marked on the specimen with the aid of a template. A cut ¼ to ⅜ in. in length shall then be made in the

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1934 Supplement to Book of A.S.T.M. Standards.

center of the 1-in. length and perpendicular to it. The specimen shall then be clamped in the jaws of the tensile strength testing machine along the non-parallel sides of the trapezoid. The initial distance between the jaws shall be 1 in., and the width of the jaws shall be 3 in. or more. One edge of the specimen shall thus be held taut while the other edge lies in folds. The machine shall then be started and the sample torn, the speed of the pulling jaw being 12 in. per minute. The pawl on the pendulum shall be disengaged from the ratchet during the test. The average load necessary to continue the tear after it has been started shall be considered as the tear resistance of the fabric. The average of five determinations in the warp and five in the filling directions shall be reported. The capacity of the machine should be such that the specimen tears in the range of maximum sensitivity.

(*b*) *Alternate Method.*—A specimen 3 in. in width and 8 in. in length shall be selected for test. A longitudinal cut 3 in. in length shall be made in the center of the specimen. One of the tongues thus formed shall be placed in the upper jaw of a tensile strength testing machine, preferably with automatic recording device, and the other in the lower jaw. The machine shall then be started and the specimen torn, the speed of the pulling jaw being 12 in. per minute. The pawl on the pendulum shall be disengaged from the ratchet during the test. The average load necessary to continue the tear after it has been started shall be considered to be the tear resistance of the fabric. The average of five determinations in the warp and five in the filling directions shall be reported. The capacity of the machine should be such that the specimen tears in the range of maximum sensitivity.

Revision submitted, June, 1930; Modified, June, 1933.

Revision[1] of Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39 - 34):[2]

Tear Resistance Test.—Add as a new Section 14 the tear resistance test procedure recommended in Specifications D 274 - 34 above, renumbering the present sections accordingly.

Elongation Test.—Add the following elongation test procedure as a new Section 15, renumbering the present sections accordingly:

Elongation

14. Unless otherwise specified, the elongation of cloth at any stated load shall be obtained when the breaking strength is determined and for the same specimens by means of a suitable autographic recording device on the testing machine. The elongation shall be the average of the results obtained for five specimens. It shall be expressed as the percentage increase in length. Since the initial length and therefore the measured elongation depend upon the load applied in placing the specimen in the jaws of the machine, an initial load just under that required to register on the dial of the machine should be used. In practice, it is advantageous to place the specimen in the machine at a somewhat lower load and to calculate the initial length of the specimen from the distance between the jaws of the machine when the test is started and the distance the jaws separate before a just perceptible load is assumed by the specimen, as shown by the graphic record.

Revision submitted, June, 1933.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1934 Supplement to Book of A.S.T.M. Standards.

Revision[1] of Standard Methods of Testing Molded Materials Used for Electrical Insulation (A.S.T.M. Designation: D 48 – 33):[2]

Section 10.—Change this section which describes the flexure test apparatus to read as follows by the addition of the italicized words and the omission of those in brackets:

10. Any standard testing machine may be used provided it is accurate to within 1 per cent for the lowest load for which it is used. The distance between points of support shall be 4 in. (102 mm.). The supports shall have the contact edges rounded to a radius of $\frac{1}{8}$ in. (3.18 mm.). The load shall be applied [parallel to and in the same direction that] ***perpendicular to the direction in which*** the molding pressure was applied, midway between the supports by a pressure piece, the bearing edge of which shall be rounded to a radius of $\frac{1}{8}$ in. (3.18 mm.).

Revision submitted, August, 1934.

Section 11.—Change this section from its present form: namely,

11. The test specimen shall be molded to the dimensions shown in Fig. 3.

to read as follows:

11. The test specimen shall be molded to the dimensions shown in Fig. 3. The thickness of the molded specimen, that is, the dimension parallel to the application of the molding pressure may be any value of $\frac{1}{2}$ in. or less agreed upon as representative of the cross section in which the material is to be used. The thickness as molded will be the width of the beam when under test.

NOTE.—When the specimen is less than $\frac{1}{4}$ in. in molded thickness difficulties may be encountered due to tipping over or unsteadiness during test. In such cases the test may be made upon a composite specimen consisting of sufficient individual pieces to aggregate approximately $\frac{1}{2}$ in. in beam width held together by a rubber band or other light clamp.

Revision submitted, August, 1934.

Section 13.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

13. The report shall include the following:

(*a*) The thickness and width ***as molded*** of each specimen [as] measured by a micrometer in inches or millimeters;

(*b*) The load on each specimen in pounds or in kilograms at the first sign of failure;

(*c*) The maximum fiber stress in pounds per square inch or in kilograms per square millimeter calculated from the formula:

$$S = \frac{3Pl}{2bd^2}$$

in which S = maximum fiber stress, P = load applied, l = distance between [the supports] ***points of support***, b = width of [specimen] ***the beam as tested***, and d = depth of [specimen] ***the beam as tested;***

(*d*) The rate at which the load was applied;

(*e*) The maximum deflection at the center in inches or in millimeters.

Revision submitted, August, 1934.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part II.

Figure 3.—Change this figure which shows the flexure test specimen by omitting the $\frac{1}{2}$-in. dimension under the side view and substituting the following note: "Thickness in accordance with Section 11." Add an arrow showing "direction of molding pressure" perpendicular to the remaining $\frac{1}{2}$-in. dimension. Retain the note under the figure caption.

Revision submitted, August, 1934.

Resistance to Impact.—Add the following as a new Section 14, renumbering the remaining sections accordingly:

14. Resistance to impact shall be determined in accordance with the Tentative Methods of Testing Electrical Insulating Materials for Resistance to Impact (A.S.T.M. Designation: D 256 – 34 T) of the American Society for Testing Materials.[1]

Revision submitted, August, 1934.

Sections 14 to 17, inclusive.—Replace this material, describing dielectric strength tests at commercial power frequencies, by the following new Section 15, renumbering the present Sections 18 to 24, inclusive, accordingly:

DIELECTRIC STRENGTH

15. The dielectric strength shall be determined in accordance with the Tentative Methods of Testing Sheet, Tape, and Molded Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 – 34 T) of the American Society for Testing Materials.[2]

Revision submitted, June, 1934.

Revision[3] of Standard Definitions of Terms Relating to Coal and Coke (A.S.T.M. Designation: D 121 – 30):[4]

The Tentative Definition of the Term Coke (D 121 – 30 T)[5] is intended to be added when adopted to the present Standard Definitions D 121 – 30.

Revision[3] of Standard Definitions of Terms Relating to Timber Preservatives (A.S.T.M. Designation: D 324 – 33):[4]

The following definition of the term "water-gas tar" is intended when adopted to be added to the Standard Definitions D 324 – 33:

Water-Gas Tar.—Tar produced in the manufacture of carbureted water gas by the decomposition of petroleum oil by heat in the presence of blue gas.

Revision submitted, June, 1933.

---

[1] See p. 995.

[2] See p. 982.

[3] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[4] 1933 Book of A.S.T.M. Standards, Part II.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1147 (1930); also 1934 Book of A.S.T.M. Tentative Standards, p. 514.

Revision[1] of Standard Definitions of Terms Relating to Methods of Testing (A.S.T.M. Designation: E 6 – 30):[2]

The definitions of the terms "elastic limit" and "yield strength" published under the title "Tentative Definitions of Terms Relating to Methods of Testing (E 6 – 32 T)[3] are intended to be added when adopted to the present Standard Definitions E 6 – 30.

---

[1] Criticisms of this revision are solicited and should be directed to the Headquarters of the Society, 260 S. Broad St., Philadelphia, Pa.

[2] 1933 Book of A.S.T.M. Standards, Part II.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part I, p. 967 (1932); also 1934 Book of A.S.T.M. Tentative Standards, p. 1170.

EXECUTIVE COMMITTEE

1934-1935

President

HERMANN VON SCHRENK

Vice-Presidents

H. S. VASSAR
(Term Expiring in 1935)

A. C. FIELDNER
(Term Expiring in 1936)

Secretary-Treasurer

C. L. WARWICK

Members

(Term Expiring in 1935)

F. A. BARBOUR
C. N. FORREST
J. C. PEARSON
A. E. WHITE

(Term Expiring in 1936)

H. A. ANDERSON
H. J. BALL
W. M. BARR
L. S. MARSH
J. B. RATHER

Past-Presidents

F. O. CLEMENTS
(Term Expiring in 1935)

CLOYD M. CHAPMAN
(Term Expiring in 1936)

T. R. LAWSON
(Term Expiring in 1937)

Assistant Treasurer

J. K. RITTENHOUSE

Assistant Secretary

R. E. HESS

COMMITTEES OF EXECUTIVE COMMITTEE

1934-1935

Finance

F. O. CLEMENTS, *chairman*
CLOYD M. CHAPMAN
T. R. LAWSON
HERMANN VON SCHRENK

Committee Activities

H. S. VASSAR, *chairman*
H. A. ANDERSON
W. M. BARR
A. C. FIELDNER

Meetings

A. E. WHITE, *chairman*
H. J. BALL
C. N. FORREST
J. C. PEARSON

Inter-Society Relations

HERMANN VON SCHRENK, *chairman*
L. S. MARSH
J. B. RATHER
A. E. WHITE

Membership

J. C. PEARSON, *chairman*
H. A. ANDERSON
H. J. BALL
C. N. FORREST

Promotional Activities

A. C. FIELDNER, *chairman*
F. A. BARBOUR
L. S. MARSH
J. B. RATHER